ModeScan™ 1780
Laser Beam
Profiler

Installation and Operation Manual

Serial # ______________________________

Date ______________________________

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1. Introduction

1.1. System Overview

1.1.1. ModeScan Model 1780

The ModeScan Model 1780 is a laser beam profiling instrument that measures the M^2 Beam Propagation Ratio and all associated ISO 11146 parameters instantaneously in real time at video rates to over 20Hz. The measurement technique, patented by Photon Inc., uses 10 reflective surfaces in the test space to form simultaneous replicas of the propagating beam at 10 locations on a CCD array camera. With all 10 measurement positions acquired at once, the instrument is suitable for measurement of both CW and pulsed lasers down to single-shot rates in the 1Hz or less range. Beam diameters are obtained with NIST-traceable accuracy to better than 2% using the Spiricon Model 2512 12-bit FireWire BeamPro. Considering other error sources this translates to M^2 measurements with accuracy to ~5%. The system operates under Spiricon's FireWire BeamPro Acquisition and Analysis Software in Microsoft Windows™. The compactness of the system and the IEEE 1394 "FireWire" interface offers enhanced ease-of-use and portability. The compactness and ability to operate in any orientation allow for easy placement on any optical bench and saves precious bench space.

The CCD is sensitive from 190nm to 1100nm wavelengths, *although recommended operation is for wavelength >250nm to avoid possible damage to the CCD.* The test lens and optical attenuation used for the measurement must be selected appropriate to the laser wavelength, beam diameter, and divergence.

The standard Model 1780 is equipped with a 200mm focal length test lens with broadband Anti-Reflection coating for the wavelength range from 425-720nm. Other focal lengths and AR coatings are available. The lenses are mounted in C-mount barrels that in turn mount into a removable cartridge or C-mount extension tubes for ease of replacement. The standard configuration is also supplied with a glass OD 2.8 C-mount neutral density filter for wavelengths >380nm, and optionally an OD 3.0 Fused Silica Inconel neutral density filter for wavelengths <380nm. For pulsed lasers with repetition rate <~10kHz and wavelength >380nm, the Ophir-Spiricon, LLC Model ATP is recommended for use with this system. For pulsed lasers with repetition rate <~10kHz and wavelength <380nm, a variable UV filter or a combination of UV filters will generally be required.

1.1.2. FireWire BeamPro Acquisition and Analysis Software

The ModeScan 1780 operates under the FireWire BeamPro Acquisition and Analysis Software. The FireWire BeamPro Software was written for Microsoft Windows Vista, Microsoft Windows XP Professional and Microsoft Windows 2000 Professional 32 bit systems, taking full advantage of the menu driven, multi-windowing environment. The software provides quantitative measurement of numerous beam spatial characteristics in accordance with the ISO 13694 and ISO 11145 standards and M^2 parameters according to the ISO 11146 standard.

The software operates in 2 modes: the M^2 Beam Propagation mode and the standard Beam Profiling mode. The M^2 Beam Propagation mode includes a live Video window for displaying the 10 beam spots, a Measurement view showing the beam caustics, and the Beam Parameters view, a tabular summary for the M^2 parameters and beam diameters with Pass/Fail analysis. Time Statistics views with strip chart time displays and summary statistics and overlays are also available, and a Notes view for entering text. In the standard mode, all the features for beam analysis are available for closer inspection of a single beam. Additional windows available are the 2D Contour and 3D views.

The ISO 11146 Standard M^2 Beam Parameters measured and reported in Propagation Mode are:

- M^2 Beam Propagation Ratio
- Divergence
- Beam Waist Diameter
- Beam Waist Location
- Rayleigh Length
- Major and Minor axes
- Astigmatism

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

ISO 13694 Parameters measured and reported include:

- Beam width
- Centroid and peak location
- Major and minor axes
- Beam orientation
- Ellipticity, eccentricity
- Gaussian fit
- Beam uniformity
- Beam divergence
- Pointing stability

Windows available for data display include:

Video	Displays live video images;

M^2 Beam Measurement Caustics	Displays the horizontal and vertical beam caustic at 10 measurement planes in the test space
Dual Aperture Profile	Displays pinhole or slit profiles;
Beam Statistics	Displays computed beam parameter values and statistics;
3D Profile View (up to 3)	Displays 3-dimensional representations of the beam intensity;
2D Contour View	Displays 2-dimensional contours of the beam intensity;
Time Statistics (up to 15)	Displays strip chart graphs of selected beam parameters;
Pointing	Displays a target screen for observing beam pointing and divergence;
M^2 Interactive Wizard	An interactive program for measuring M^2 by the Rayleigh Method;
Notes	A simple text editor for entering user annotations;

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.

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. ModeScan Model 1780 System Specifications

Model 1780	Specification
Sensor:	Si CCD 1/2" Format
Wavelength:	380nm–1100nm (Standard configuration with OD 2.8 filter) 250nm–1100nm (Sensor only)
Pixel Array:	780 (H) × 580 (V)
Pixel Size:	8.3µm × 8.3µm
Array Dimension:	6.49mm × 4.83mm
Scanning Mode:	Progressive
A / D Conversion:	12 Bit
Signal to Noise Ratio (maximum)	58.4dB
Maximum Frame Rate:	35.8fps (full frame @ full resolution)
Exposure range:	20µs–27.64ms (Software selectable via 1394 bus)
Gain:	0 – 12dB (Software selectable via 1394 bus)
Image Plane:	17.526mm from the C-mount front surface
Trigger:	Internal or External (Software selectable)
External Trigger Specifications:	5V ± 1V @ 10mA ± 5mA (Positive transition)
Trigger Connector:	10 pin RJ-45 Jack
Trigger Cable:	10 pin RJ-45 to BNC 1.8m
Interface:	IEEE 1394a (FireWire)
IEEE 1394 Cable Length:	1.8m (standard)
Supply Voltage:	+8V – +36V DC (+12V DC nominal), <1% ripple (supplied via IEEE 1394 cable); requires external-powered hub with laptop PCs
Supply Power:	3.5W max @ 12V DC (typical)
Filter/Lens Mount:	C-mount (1"-32 tpi) – 2.8 ND
Operating temp:	O° - +50°C (+32°-112F)
Humidity:	20%-80%, relative, non-condensing
Conformity:	CE; FCC; RoHS and WEEE
Mounting:	Gimbal Mount on ½" post; 12mm Metric post optional
Dimensions:	62mm H × 140mm W × 210mm L + Gimbal Mount
Weight	~ 1.4kg
CCD Cover Glass	Removed to eliminate interference fringes
Beam Splitters	Fused Silica: <20/10 Scratch Dig, l/10 Flatness

Test Lenses Visible Option UV Option NIR	 200mm fl BK7/455-720nm AR coated standard; other fl's optional 200mm fl Fused Silica/250-460nm AR coated standard; other fl's optional 200mm fl BK7/620-1080nm AR coated standard; other fl's optional
Fixed Attenuator Visible-NIR UV	 OD 2.8 Absorbing Glass >360nm OD 3.0 Fused Silica Inconel 250-450nm

All Specifications are subject to change without notice.

WARRANTY INFORMATION

Spiricon'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. Spiricon cannot be held liable for any damages beyond the original equipment cost.

Spiricon 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.

Spiricon 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 Ophir-Spiricon, LLC. Unauthorized transfer of equipment and/or modification to the equipment is grounds for voiding warranty coverage.

Spiricon 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 Spiricon'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 Spiricon, which is not contained in this warranty will be binding upon Spiricon, unless made in writing and executed by an officer. Spiricon 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 Spiricon and excluded from this agreement. Under no circumstances shall Spiricon be liable to Buyer in contract or in tort, for any special, indirect, incidental or consequential damages, expenses, losses or delays however caused.

Spiricon must be notified of the defect or nonconformity within the warranty period and the affected product returned to Spiricon's factory or an authorized service center within 30 days after the discovery of such defect or nonconformity. Shipment to Spiricon shall be made with an RMA# and prior authorization by Spiricon. 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 ModeScan 1780 M² measurement system has been carefully tested, inspected, and packaged prior to shipment. Spiricon performs extensive testing to ensure that the unit is in proper working order. Upon receipt, please inspect your FireWire BeamPro system for the following:

- Note any damage to the shipping container. Please report any damage found immediately to the shipping company. Spiricon 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 Spiricon to activate your warranty.

2.2. ModeScan 1780 System Packing List

The following items are shipped as part of the standard ModeScan 1780 System:

- ModeScan 1780 Scan Unit including 200mm fl lens and OD2.8 filter for wavelength >380nm.
- FireWire BeamPro Acquisition and Analysis Software CD for Windows Vista, Windows XP Professional or Windows 2000 Professional 32 bit systems
- FireWire (IEEE 1394a) cable
- External trigger cable: RJ-45 10-pin to BNC
- Operating Manual

3. System Setup

3.1. Personal Computer Requirements

To ensure the successful installation and operation of the ModeScan 1780 system, operating under the FireWire BeamPro Acquisition and Analysis Software, verify that your PC has the following minimal requirements:

- 1.8GHz or faster Pentium IV Processor (32-bit architecture)
- Microsoft Windows Vista, Microsoft Windows XP Professional SP1 (or higher) or Microsoft Windows 2000 Professional SP3 (or higher) Operating System
- OHCI Compliant IEEE-1394a (FireWire) Adapter
- 512 MB of RAM
- CD-ROM Drive
- 30MB free space on hard disk
- 64MB Color SVGA Graphics Card
- SVGA Display Monitor
- Mouse or other Pointing Device
- Keyboard

3.2. ModeScan 1780 Camera Installation

Proper operation of the ModeScan 1780 FireWire BeamPro camera requires a standard 6-pin IEEE-1394 connector. These 6-pin connectors can usually be found on desktop PCs or on PCI IEEE-1394 adapter cards.

To install the camera connect one end of the 6-pin IEEE1394 cable provided with the system to the camera connector and the other end to the 6-pin port at the PC.

Some laptop PCs provide a built-in 4-pin IEEE-1394 connector that does not provide power to the camera. In this case you will need to have an IEEE-1394 powered hub inline (like the SIIG 1394 hub, PN: NH-H6012).

Note: *We do not recommend the operation of the FireWire BeamPro with laptop computers that do not have a built in IEEE-1394 port. Although there are powered PC-Card IEEE-1394 interfaces available, we have found that they do not work reliably with these cameras.*

Caution! Exercise care when applying power to your FireWire hub; connection of a power supply with incorrect polarity/voltage will damage the camera.

3.3. Software Setup

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

3.3.1. Installation

1. Insert the **FireWireBeamPro CD** into the CD Drive. Open Windows Explorer and browse to **FireWireBeamPro CD** and double click the **setup.exe**.
2. Follow the instructions and, if it is possible, accept the default (suggested) settings.

3.3.1.1. Microsoft Windows Vista only

3. Click **Allow** when prompted by the UAC (User Account Control); there will be two prompts during the installation.

3.3.2. Uninstallation

3.3.2.1. Microsoft Windows Vista

1. Open the **Control Panel** by clicking **Start** then selecting **Control Panel**.
2. Click on the word **Uninstall a program** under the programs heading.
3. Select **FireWire BeamPro** and then click the **Change** button. Click **Next**, select **Remove**, and then click **Next** to confirm your selection. Click **Remove** to start uninstalling the software. Click **Allow** when prompted by the UAC. Click **Finish**.
4. Select **Basler Pylon Viewer 2.0.0.566** and then click the **Uninstall** button. When prompted click **yes** to start removing the software. Click **Allow** when prompted by the UAC.
5. This completes the uninstall procedure for the software.

3.3.2.2. Microsoft Windows XP Professional

1. Open the **Control Panel** by clicking **Start** then selecting **Control Panel**.
2. Click the **Add or Remove Programs** icon
3. Select **FireWire BeamPro** and then click the **Change** button. Click **Next**, select **Remove**, and then click **Next** to confirm your selection. Click **Remove** to start uninstalling the software. Click **Finish**.
4. Select **Basler Pylon Viewer 2.0.0.566** and then click the **Uninstall** button. When prompted click **yes** to start removing the software.
5. This completes the uninstall procedure for the software.

3.3.2.3. Microsoft Windows 2000 Professional

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 **FireWire BeamPro** and then click the **Change** button. Click **Next**, select **Remove**, and then click **Next** to confirm your selection. Click **Remove** to start uninstalling the software. Click **Finish**.
4. Select **Basler Pylon Viewer 2.0.0.566** and then click the **Uninstall** button. When prompted click **yes** to start removing the software.
5. This completes the uninstall procedure for the software.

4. System Operation

4.1. ModeScan 1780 Hardware

The ModeScan Model 1780 is a compact unit comprising the Optics Enclosure with Beam splitters, an OD2.8 Filter, the Removable Lens Cartridge, Interchangeable Lenses in C-mount barrels, the Firewire 12-bit CCD camera, a 2-axis Gimbal Stage, an Iris Entrance Aperture, and optional C-mount extension tubes. The unit is shown in Figure 4.1. Cables include an IEEE1394a Firewire cable and a BNC/10-Pin RJ-45 Jack External Trigger Cable.

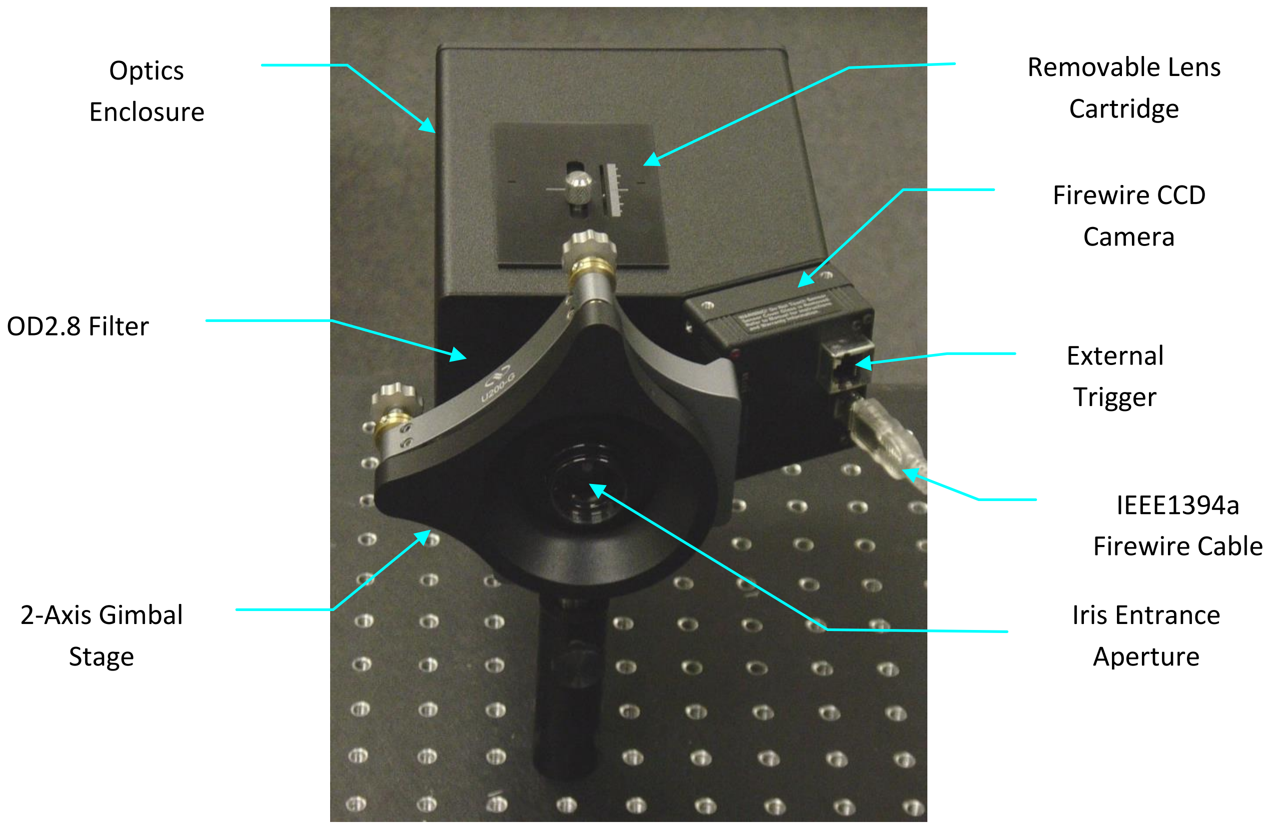


Figure 4.1. The ModeScan Model 1780

The optical “axis” of the unit is the path from the center of the Iris Entrance Aperture to the beam splitters and back to the nominal center of the CCD array.

4.1.1. Removable Lens Cartridge

The removable lens cartridge is for mounting lenses with 175-250mm focal length. The lenses are inserted into C-mount barrels that in turn attach to the lens mount frame, as shown in Figure 4.2 and Figure 4.3.

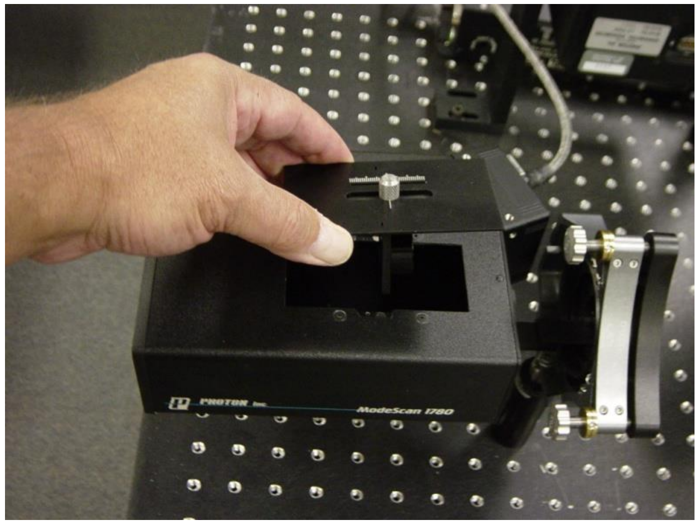


Figure 4.2. Removable lens cartridge.

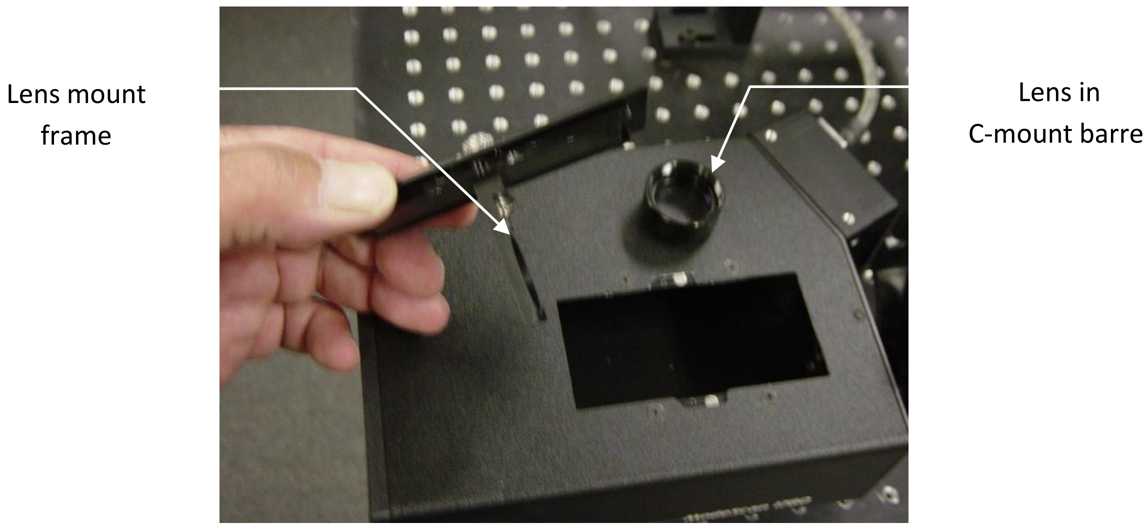


Figure 4.3. Lens Cartridge with lens removed.

A detail of the lens cartridge in the optics enclosure is shown in Figure 4.4. The position of the lens can be adjusted over a range of ±18mm. The lens position is indicated on the position scale scribed onto the Lens Cartridge. The large scribe line is the "0" position. The small scribes are 1mm increments, with “+” settings toward the front of the ModeScan and “-” settings toward the rear. The lens should be positioned at the “0” position for removal.

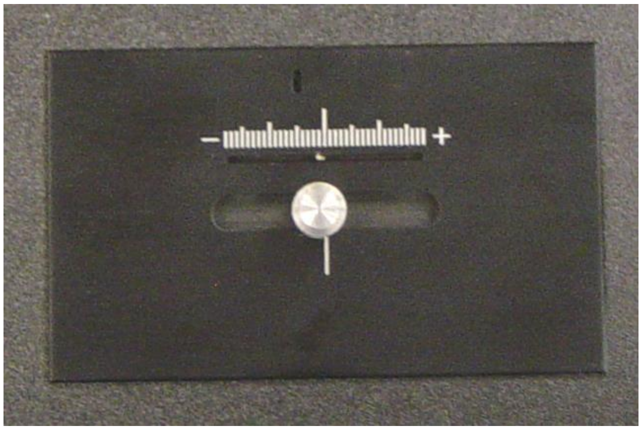


Figure 4.4. Position Scale on Lens Cartridge. The large scribe line is the "0" position. The small scribes are 1mm increments, with “+” settings toward the front of the ModeScan (right in the picture) and “-” settings toward the rear. In this photo the lens is at position “-1mm”.

4.1.2. Lenses

Standard and accessory lenses provided with the ModeScan 1780 are either BK-7 for visible and NIR wavelengths, or UV Grade Fused Silica for UV wavelengths. These lenses are broadband AR coated for the wavelength ranges of use. The broadband AR coatings cover 3 wavelength regions: UV, VIS, and NIR. The wavelength ranges are shown in Table 4.1.

Table 4.1 Wavelength Ranges for the Broadband AR Lens Coatings

AR Coating	Wavelength Range (nm)
UV	250-460
VIS	425-720
NIR	620-1080

The focal lengths of the lenses are specified at a wavelength of 589nm to ±1% accuracy. However, since the refractive index of the lens materials changes with wavelength, it is necessary to determine the focal length for the wavelength of use in order to obtain the specified measurement accuracy of the ModeScan 1780. Figure 4.5 and Figure 4.6 give the lens focal length correction factors for UV grade fused silica and BK-7 lenses.

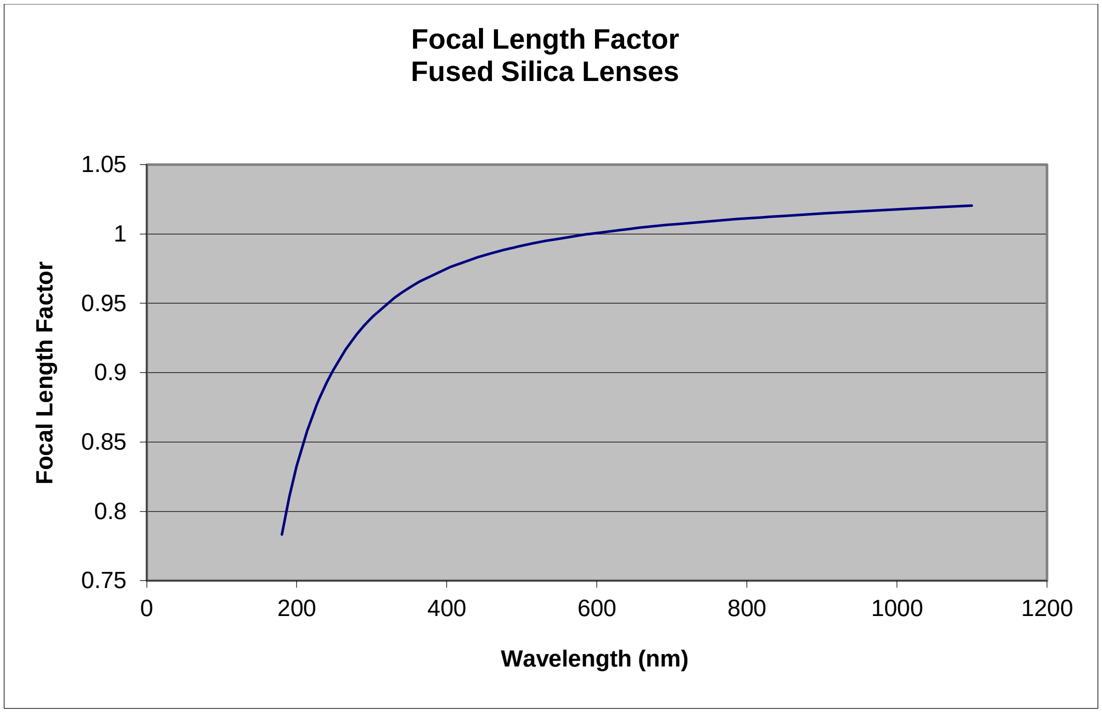


Figure 4.5. Lens focal length correction factor for UV Grade fused silica lenses.

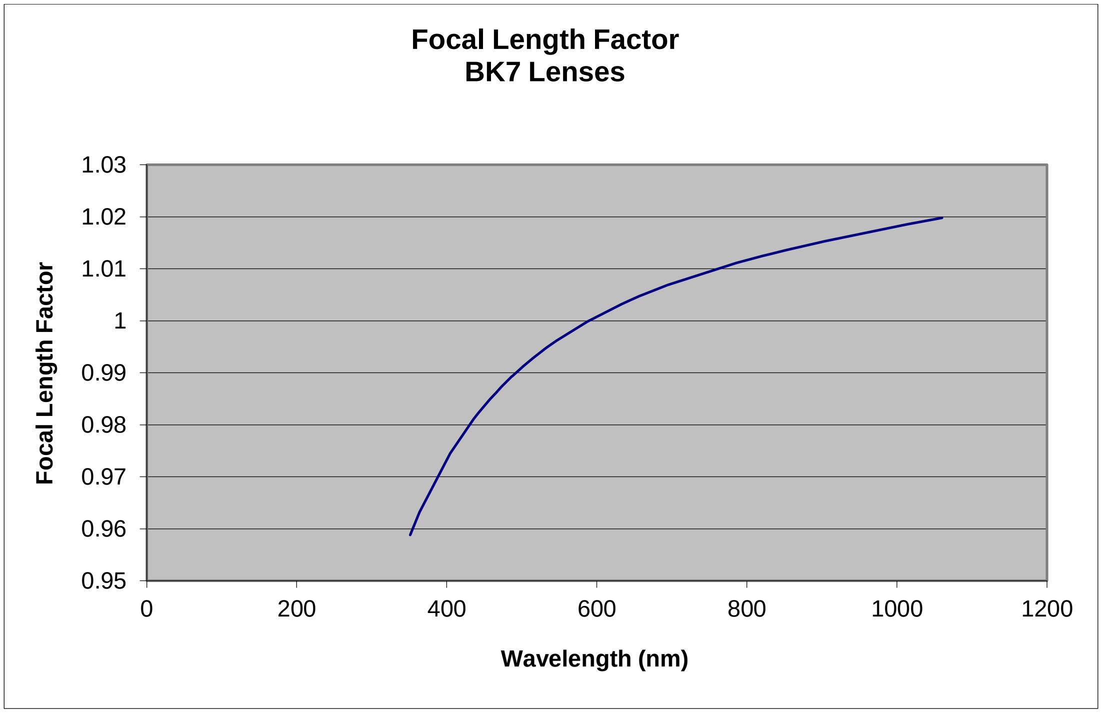
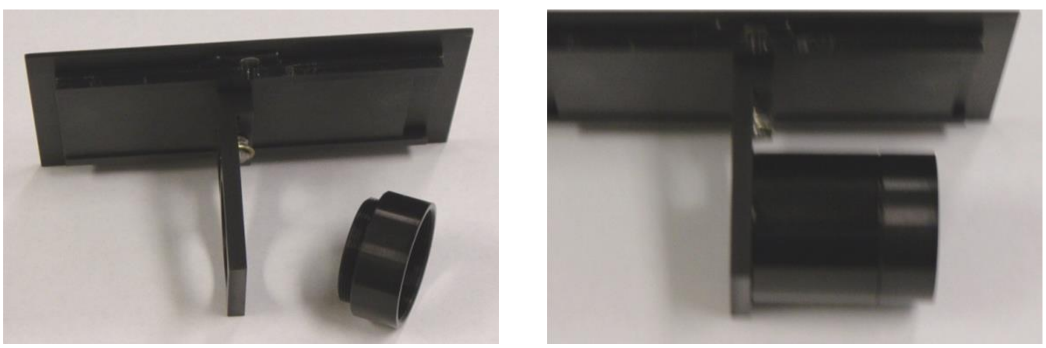


Figure 4.6. Lens focal length correction factor for BK-7 lenses.

4.1.3. Lens C-mount Extension Tubes

Lens C-mount extension tubes are used to change the lens mount position in the lens cartridge, and for lenses with focal length ≥400mm that are mounted outside the enclosure. Figure 4.7 shows a standard C-mount lens barrel screwed into the lens cartridge. Figure 4.8a shows the C-mount lens barrel detached from the cartridge. Figure 4.8b shows the C-mount lens and a 40mm C-mount extension tube in the lens cartridge. The length of any extension tubes must be included in the lens position that is entered in the software. For example, if the lens cartridge indicator is –7mm, and a 40mm extension tube is used as in Figure 4.8b, then the value to enter into the software is 33.

Figure 4.7. C-mount lens barrel attached to the lens cartridge.



a.) b.)

Figure 4.8. Lens C-mount barrel detached from the lens cartridge, a.) and b.) 40mm C-mount extension tube with C-mount lens barrel attached to lens cartridge.

An example of a lens mounted outside the enclosure is shown in Figure 4.9. Here a 100mm tube is shown attached to the Iris Entrance Aperture C-mount threads. The lens barrel attaches to the tube with C-mount threads.

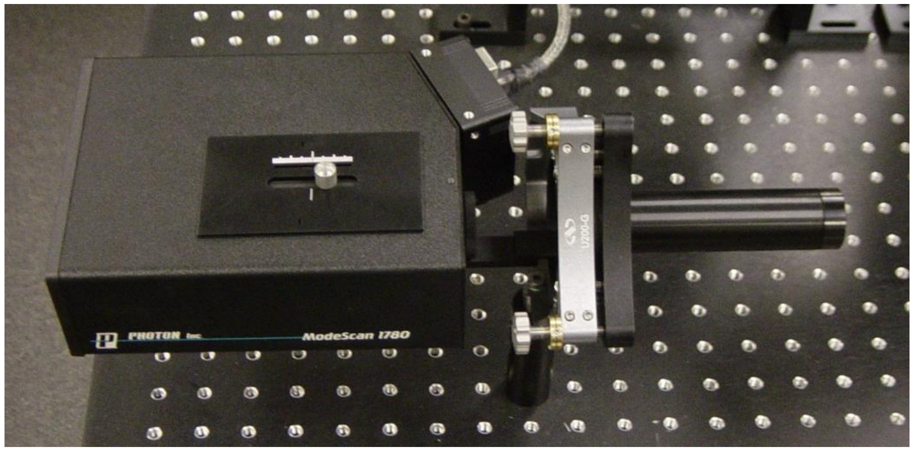


Figure 4.9. ModeScan 1780 with 100mm lens mount extension tube attached to the Iris Entrance Aperture.

4.2. ModeScan 1780 Software

The ModeScan 1780 operates under the FireWire BeamPro Acquisition and Analysis Software. The FireWire BeamPro Software was written specifically for Microsoft Windows XP Professional or Microsoft Windows 2000 Professional and takes full advantage of the menu driven, multi-windowing environment. The software provides quantitative measurement of numerous beam spatial characteristics in accordance with the ISO 13694 standard and M^2 parameters according to the ISO 11146 standard.

The software operates in 2 modes: the M^2 Beam Propagation mode and the standard Beam Profiling mode. The M^2 Beam Propagation mode includes a live Video window for displaying the 10 beam spots, a Measurement view showing the beam caustics, and the Beam Parameters view, a tabular summary for the M^2 parameters and beam diameters with Pass/Fail analysis. Time Statistics views with strip chart time displays and summary statistics and overlays are also available, and a Notes view for entering text. In the standard mode, all the features for beam analysis are available for closer inspection of a single beam. Additional views available are the 2D Topographic, and 3D views.

For data display and visualization, the user can arrange and size these multiple windows as required. These may contain, for example as shown below in Figure 4.10, the Video, Measurement, and Beam Parameters views. Such custom-configured instrument screens with multiple views can be saved as configuration files for repeated use.

Data can be saved as program files, or 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.

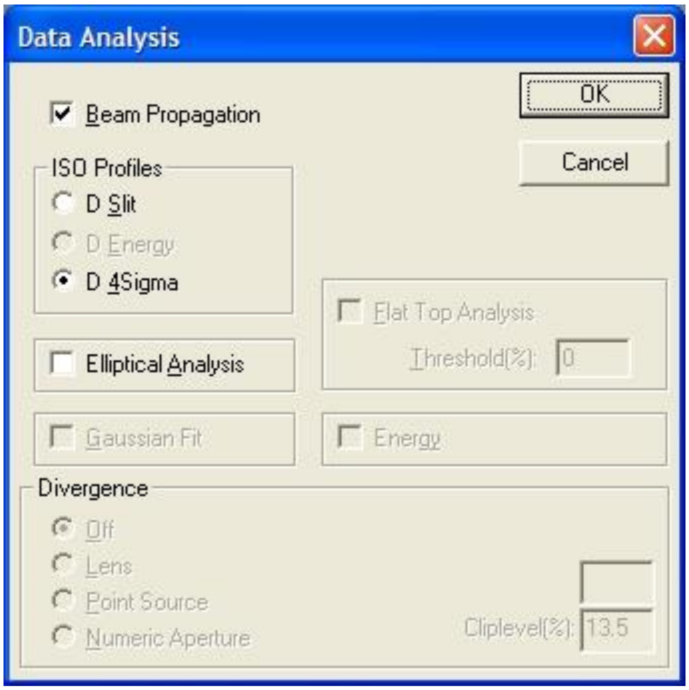
4.2.1. Launch the Program

To run the FireWire BeamPro Acquisition and Analysis Software program:

Select the **FireWire BeamPro** icon from your desktop, or from the Windows **Start** menu, select **Programs**, then **Photon**, and then **FireWire BeamPro**.

After installation when the program is **first** started, the **Video** window will appear and the program will be in the standard **Beam Profiling** mode.

In the **Data Collection** menu select **Data Analysis** to open the **Data Analysis** dialog. Select the Beam Propagation Mode and D 4Sigma for ISO Profiles. Select Elliptical Analysis if the beam is elliptical. When the dialog is closed The **Video** window will rotate 90° and may resize.



At this point the ModeScan 1780 GUI can be configured as desired with the multiple windows available. Alternatively, an example startup GUI configuration screen is available that can be opened from the **File** menu. This example GUI is shown in Figure 4.10. The example configuration file name is "Example ModeScan1780.fwc" and can be found in the directory where the software was installed, (default directory is "C:\Program Files\Photon\FireWire BeamPro"). There are 3 views on this sample screen, including:

- **Video** view
- **Beam Statistics** view
- **Measurement** view

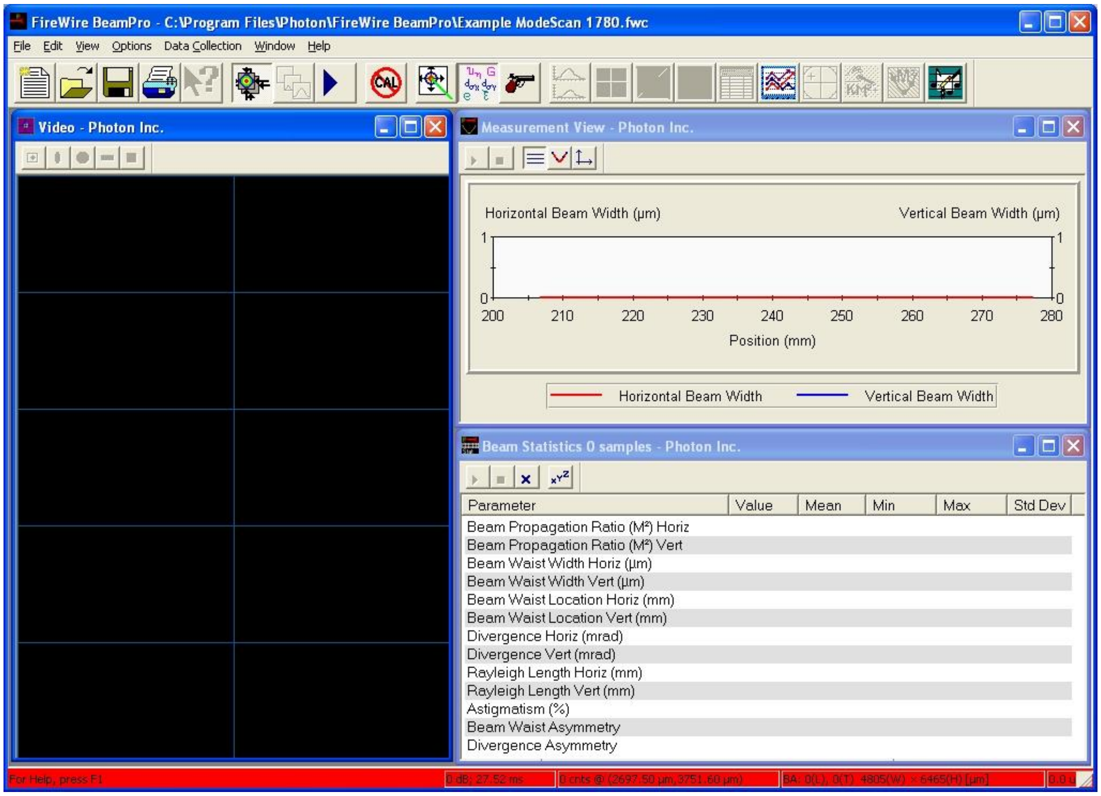
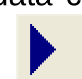


Figure 4.10 Example ModeScan GUI configuration file, with the Video, Beam Statistics, and Measurement views.

At first startup, the system will NOT be collecting data. Turn on global data collection from the Data Collection menu or use the global data collection icon  on the toolbar. Refer to chapter 5 for a full description of the software.

4.2.2. Trigger Mode for Pulsed Lasers

If your laser is CW, skip this step.

To measure pulsed laser beams, use the **External** Trigger Mode. The Trigger Mode can be changed through the **Data Collection** menu. Open the **Trigger Mode** menu and select **External**. The **Pulsed** selection is not available for the Beam Propagation mode.

The External Trigger acts like an Asynchronous Reset for the camera integration or exposure period. It is therefore necessary to apply the trigger before the occurrence of the laser pulse, or in other words it requires a PRETRIGGER signal. The specifications for the external trigger are given in section 4.12. The trigger occurs on the positive-going (leading) edge of the signal, and this must occur at least 32µs before the laser pulse, as shown in the timing diagram in Figure 4.24.

4.2.3. Beam Propagation dialog

The Beam Propagation dialog is used to enter parameters for the M^2 measurement. These are the laser wavelength, laser position relative to the ModeScan 1780, the lens focal length for the wavelength of use, and the lens position.

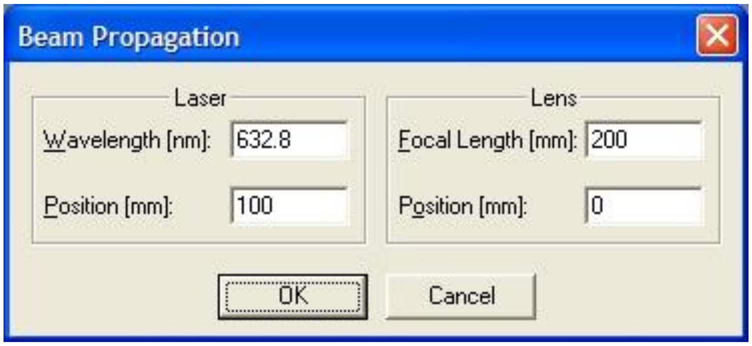


Figure 4.11 shows the geometry for the Beam Propagation position parameters. Enter the position parameters after the Optical Alignment and Lens position Adjustment have been performed.

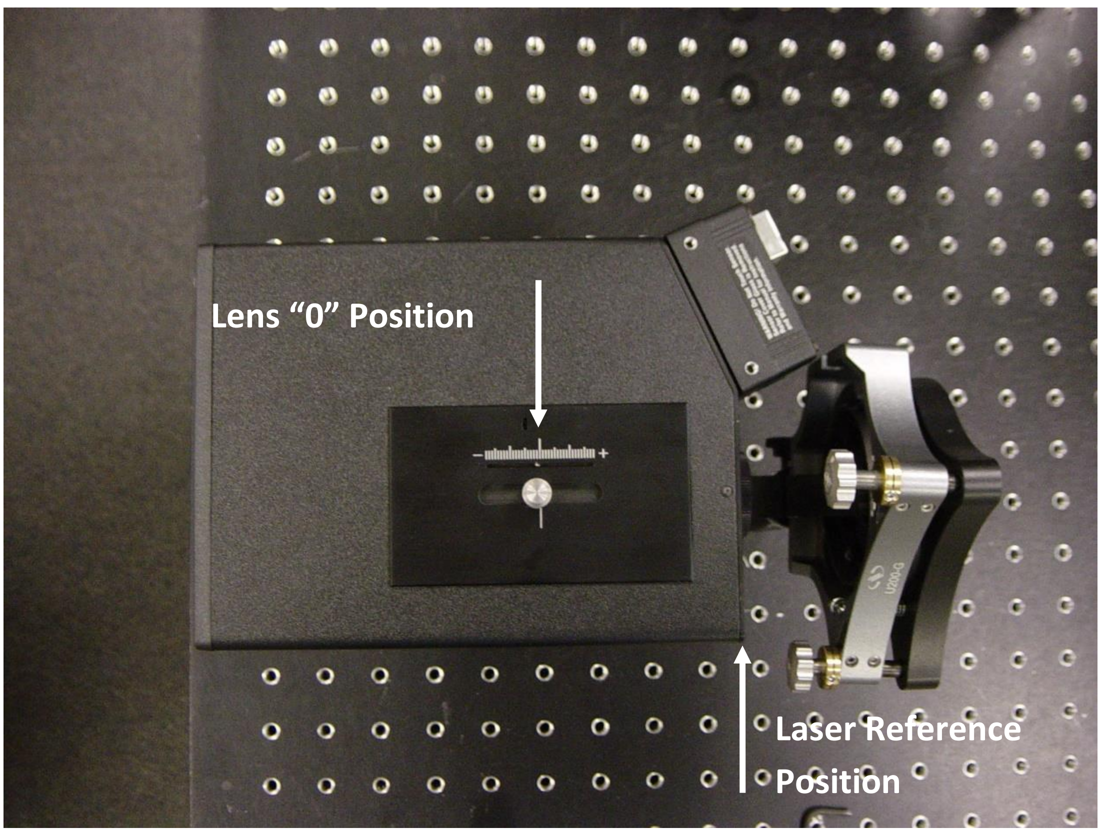


Figure 4.11. Geometry for the Beam Propagation parameters. The lens “0” reference position is the long scribe line, with + distances toward the gimbal mount. In the figure the lens position is approximately –2mm. The reference for the laser position is the front surface of the optics enclosure, indicated in the figure.

4.3. Principle of Measurement

The measurement technique, patented by Photon Inc., uses 5 fused silica laser-grade optical flat beam splitters (10 reflective surfaces) in the test space to form simultaneous samples of the propagating beam at 10 locations on a CCD array camera. With beam profiles at all 10-measurement positions acquired simultaneously, the instrument measures both CW and pulsed lasers down to single-shot rates.

The CCD array is segmented into 10 regions of analysis as defined by the blue grid in the Video view. When the system is aligned, 1 beam from each of the 10 reflective surfaces is incident upon each sub region. This can be seen in Figure 4.12, which shows the Video view from the ModeScan software.

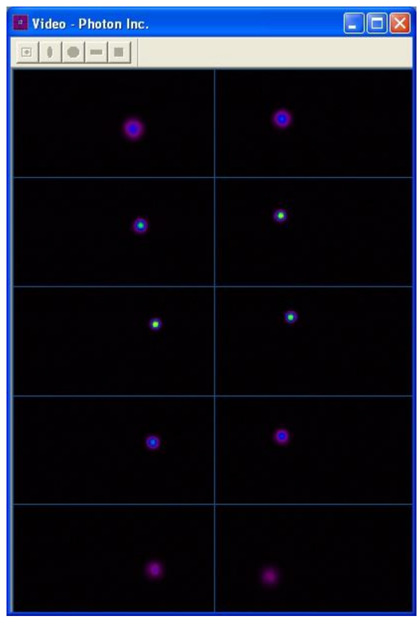


Figure 4.12. Video view from the ModeScan software showing 10 beams incident upon the CCD array, with 1 beam per region of analysis.

The horizontal “x” and vertical “y” beam diameters (or major and minor if in Elliptical Analysis) are obtained for each of the 10 measured spots. These are used to generate the beam propagation caustics that are displayed in the Measurement view. An example Measurement view is shown in Figure 4.13.

A hyperbolic fit is generated that best fits the beam caustic data, and from these fits the ISO Standard 11146 M^2 parameters are obtained.

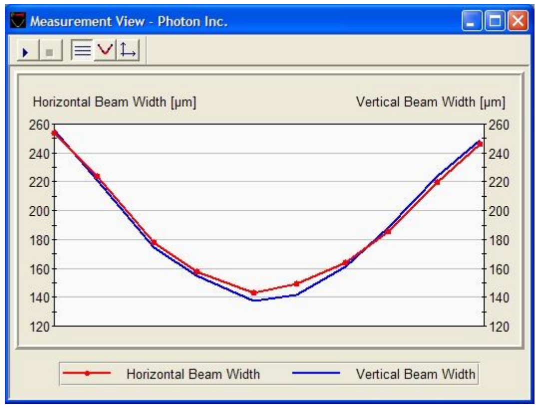


Figure 4.13. Example Measurement view with the 2 measured beam caustics.

4.4. Optimal Measurement Configuration

The 10 sampled beam positions in the ModeScan 1780 span a fixed optical distance of approximately 7.2cm. The "optimal" measurement configuration takes this span into account together with the dynamic range of the CCD camera and considerations of beam measurement accuracy to determine an optimal Rayleigh range in the test space. This yields data for beam diameter that is accurate, and ensures accuracy in the propagation caustic hyperbolic fit.

In practice, the system attenuation and/or gain and exposure settings are set to yield near full-scale values for peak profile signal for the measurements near the beam waist. For the 12-bit data acquisition, this full-scale value is approximately 4000 counts. The 2% accuracy specification is valid down to measured peak signal value of approximately 400cnts, and this determines the range for optimal measurement. This equates to a beam diameter approximately 3.16d_0, where d_0 is the waist diameter, and this translates to a measurement that is 3 Rayleigh ranges from the waist. This gives Z_R = 1.2cm. This is the smallest acceptable Rayleigh range that assures the 2% accuracy. For fit accuracy it is also desirable to have some data at least 2 Rayleigh ranges from the waist, and this corresponds to a beam diameter of 2.24d_0, and gives Z_R = 1.8cm. This is the largest acceptable range for measurement accuracy. In conclusion, the specified accuracy is achieved when the Rayleigh range in the test space is 1.2 –1.8 cm.

4.5. Performing Measurements

The following steps should be performed to make successful measurements with the ModeScan 1780. The ModeScan 1780 should be placed such that the Rayleigh range of the laser in the test space is optimized to the fixed measurement range of the ModeScan 1780. This usually involves a careful selection of lens focal length and position relative to the laser.

1. Run the ModeScan 1780 Calculator for the laser under test to theoretically determine the optimum lens focal length and the nominal positions of the lens and the ModeScan with respect to the laser. The specified accuracy is only achieved when the Rayleigh range of the laser in the test space is optimized for the

measurement range of the ModeScan 1780. See section 4.7 for a discussion of the calculator and how to use it.

2. Determine the appropriate laser beam attenuation and install it. Laser beam attenuation must be in place to reduce the laser beam to power levels that can be measured with the CCD camera. See section 4.9 for a discussion of beam attenuation.
3. Launch the software; see section 4.2 and chapter 5 for discussion of the software.
4. Configure the test lens with the ModeScan and install the ModeScan in the laser beam path as specified by the calculator.
5. Perform the Initial Placement of the ModeScan in the laser beam path. See section 4.10.1.
6. Perform the Coarse Alignment. See section 4.10.2. In this step it is helpful to set the camera exposure to maximum and/or reduce the attenuation so that the CCD images will be saturated. This makes it easier to find the beams. When the beams are found, adjust the exposure or the attenuation to set the intensity of the smallest beam diameter profile on the CCD camera to near full scale.
7. Perform the Fine Alignment of the Laser Beam to remove Horizontal Skew and optimize the Vertical Separation. See section 4.10.3.
8. Perform the Fine Alignment of the ModeScan 1780. See section 4.10.4.
9. Adjust the lens position to place the waist at the center, and readjust the exposure or attenuation if necessary.
10. Calibrate the CCD camera.
11. Enter the laser beam test parameters in the Beam Propagation dialog: parameters include the laser wavelength, Laser-ModeScan distance, test lens focal length, and the test lens position. Be sure to enter the lens focal length for the wavelength of use as discussed in section 4.1.2.
12. Observe the M^2 measurement and the reported parameters in the software GUI.

4.6. ModeScan 1780 Operating Space

The Operating Space of the ModeScan 1780 is determined by the minimum and maximum spot sizes measured accurately with the CCD camera. It is a plot of measurable divergence in the test space versus wavelength, as determined from the spot size range and the ModeScan wavelength range of 250-1100nm. The minimum $1/e^2$ spot size measured with 2% NIST traceable accuracy is 64μm. The maximum spot size is approximately 1.3mm. The corresponding operating space for M^2=1 is shown in Figure 4.14. The operating space moves up proportionally to higher divergence values as M^2 increases.

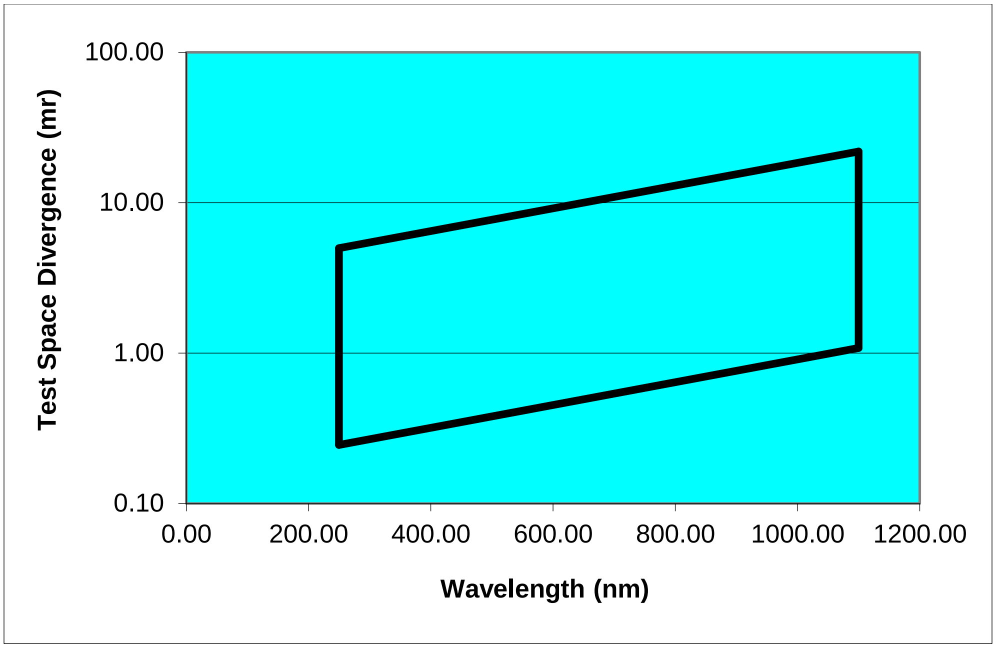


Figure 4.14. ModeScan 1780 Operating Space for M^2=1.

The divergence in the test space is determined from the divergence and Rayleigh range of the laser under test, the focal length of the test lens, and the position of the test lens relative to the waist locations of the laser under test. Unfortunately there is circular logic here, as the divergence, Rayleigh range and waist positions are often nominal only and it is the M^2 measurement that provides the final values. Therefore it is necessary to use the nominal laser parameters as a starting point to perform calculations to transform the laser space into the test space to determine the suitability and optimization of the ModeScan 1780 measurement configuration. This process is simplified using the ModeScan Calculator, an Excel spreadsheet that performs computations for configuring the ModeScan 1780 based on the nominal laser parameters for different focal length test lenses and lens positions. This calculator is described in section 4.7.

4.7. ModeScan 1780 Calculator

The ModeScan 1780 calculator is an Excel spreadsheet that computes laser propagation parameters in the laser space and in the test space based on the nominal specified laser beam wavelength, beam exit diameter, and beam divergence, and the test lens focal length and position. The calculator is based on Gaussian beam propagation equations. An example is shown in Figure 4.15 for a Helium Neon laser. You must have at least Excel 2000 installed on your computer to run the calculator.

The calculator can be found in the folder where the software has been installed (the default settings is “C:\Program Files\Photon\FireWire BeamPro”*)*. A shortcut to open the calculator can be found under the Windows **Start** menu; select **All Programs** (or **Programs)**, then **Photon**, and then **ModeScan 1780 Calculator.**

Laser Specifications

Name	**HeNe**	
Wavelength(nm)	**632.8**	**Enter in Software**
Exit Diameter: D_L(µm)	**500**	
Divergence(mR)	**1.7**	
Specified M^2	**1.02**	
Calculated D_{waist}(µm)	**483.4**	**OK**
Calculated Waist-Exit Distance: z_{WE}(m)	**0.075**	
O'Shea's z_2(m)	**1.103**	
Focal Length(m)	**0.2**	**Enter in Software**
Laser-Lens Distance: z_{LL}(m)	**1.028**	
ModeScan-Laser Distance: z_{ML}(m)	**0.956**	**Enter in Software**

Calculations

Laser Space		
Far Field Diameter at Lens: $D(z_{LL})$(µm)	$D(z_{LL})=D_L+2z_{LL}\tan\theta/2$	2247.6
Propagation Diameter from Calculated Waist	$d(z_2)=\{D_{waist}^2+\theta^2 z_2^2\}^{1/2}$	1936.6
Rayleigh Range (m)	$Z_R=4\lambda M^2/\pi\theta^2$	0.2844
O'Shea's alpha	$\alpha=\lvert f\rvert/SQRT\{(z_2-f)^2+z_R^2\}$	0.211
Test Space		
Waist Position(m)	$z_1'=f+f^2(z_2-f)/\{(z_2-f)^2+z_R^2\}$	0.240
Divergence(mR)	$\theta'=\theta/\alpha$	8.048
Rayleigh range(cm)	$Z_R'=\alpha^2 Z_R$(cm)	**1.2688**
Waist Diameter(µm)	$d_0'=\alpha d_0$	102.1
Spot Size for Optimal Range	$d_o=.0127\theta$	102.2
ModeScan-Lens Position(mm)	**-72.40**	**Lens Maybe Inside**
Software Lens Position	**-3.15**	**Enter in Software**
Lens within Adjustment Range?	**YES**	TRUE

Focal Length(m) for 65µm Spot 0.14

Lens Focal Length OK

Z_R' Optimal = 1.9623(cm)

Z_2(m) for Z_R' = 1.27cm **1.103**

Laser-Lens Distance for Z_R' = 1.27cm **1.028**

Laser-Lens Distance OK

Figure 4.15. The ModeScan 1780 Calculator Excel spreadsheet.

After the laser parameters and the focal length are entered, the spreadsheet calculates a laser-lens distance that gives an optimal Rayleigh Range in the test space. This optimal range yields beam diameters at the endpoints that are approximately 3X the diameter at the waist. Under this condition and when the caustic is centered approximately about the beam waist, 4 of the outer spots are beyond 2 Rayleigh lengths in the “far” field. This measurement configuration gives good results for the hyperbolic fit that is made to the measured beam spots.

4.8. CCD Operating Space Charts

4.8.1. CW Operating Space Chart

The CW Operating Space chart shows the range of power in Watts at a given wavelength that can be measured versus the $1/e^2$ beam diameter using the camera exposure and gain settings. The chart is useful for determining the proper attenuation for the laser beam under test. The operating space chart for 532nm is shown in Figure 4.16. The “operating space” is the region enclosed by the black lines. The left boundary is 64μm and the right boundary is at 3mm. The upper boundary is for minimum exposure and gain, and the lower boundary is for maximum exposure and gain. The red line in the chart corresponds to the thermal lensing level for absorbing glass filters. For power levels below this it is sufficient to use only absorbing glass filters, such as are used in the Spiricon ATP-K Variable Attenuator. For power levels above this, it is necessary to use wavelength specific interference filters with AR coatings, and/or laser grade fused silica wedges that provide a 4% reflection from the front surface.

For other wavelengths the Power axis scales inversely with the CCD responsivity at that wavelength. The responsivity curve is given in Figure 4.18.

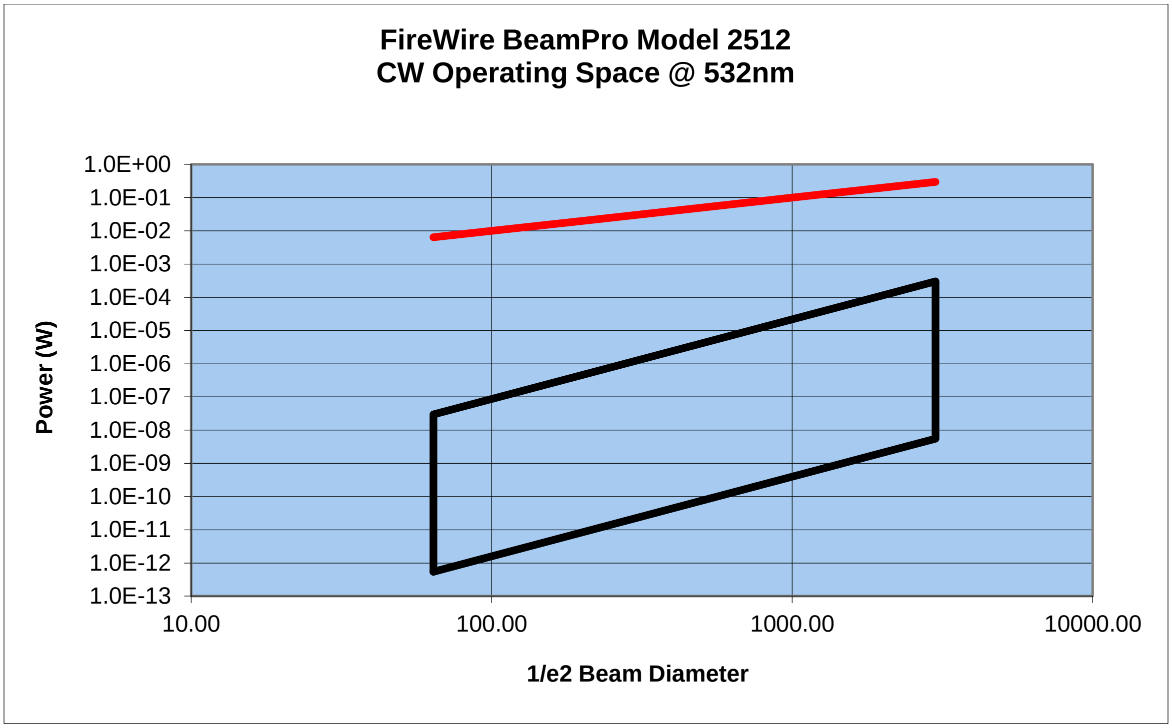


Figure 4.16. CW Operating Space Chart for the CCD camera at 532nm.

4.8.2. Pulsed Operating Space Chart

The Pulsed Operating Space chart shows the range of energy in Joules at a given wavelength that can be measured versus the $1/e^2$ beam diameter using the gain settings. Camera exposure is not included here because generally it is not useful for single shot lasers. Thus the operating region is smaller than that for CW lasers shown in Figure 4.16. However, for pulsed lasers with high repetition rate exposure is useful, but for these lasers the CW space chart can be used with the average power of the laser. As an example, consider a 4kHz pulsed laser. Pulses occur every 250μs, but the full frame exposure is 27.64ms. With a granularity of 20μs, the exposure control can be used to control exposure to 1 part in 110.6 (27.64ms/250μs). Similarly a laser operating at 1kHz could be adjusted to 1 part in 27.64.

The chart is useful for determining the proper attenuation for the laser beam under test. The pulsed operating space for 532nm is shown in Figure 4.17. The "operating space" is the region enclosed by the black lines. The left boundary is 64μm and the right boundary is at 3mm. The upper boundary is the saturation level or full-scale level of the CCD at minimum gain, and the lower boundary is for a signal of 1/10th full scale at maximum gain. The red line is the 5J/cm2 level, which is a typical damage level for many optical components. Above this level it is necessary to use fused silica wedges that provide a 4% reflection from the front surface.

For other wavelengths the Power axis scales inversely with the CCD responsivity at that wavelength. The responsivity curve is given in Figure 4.18.

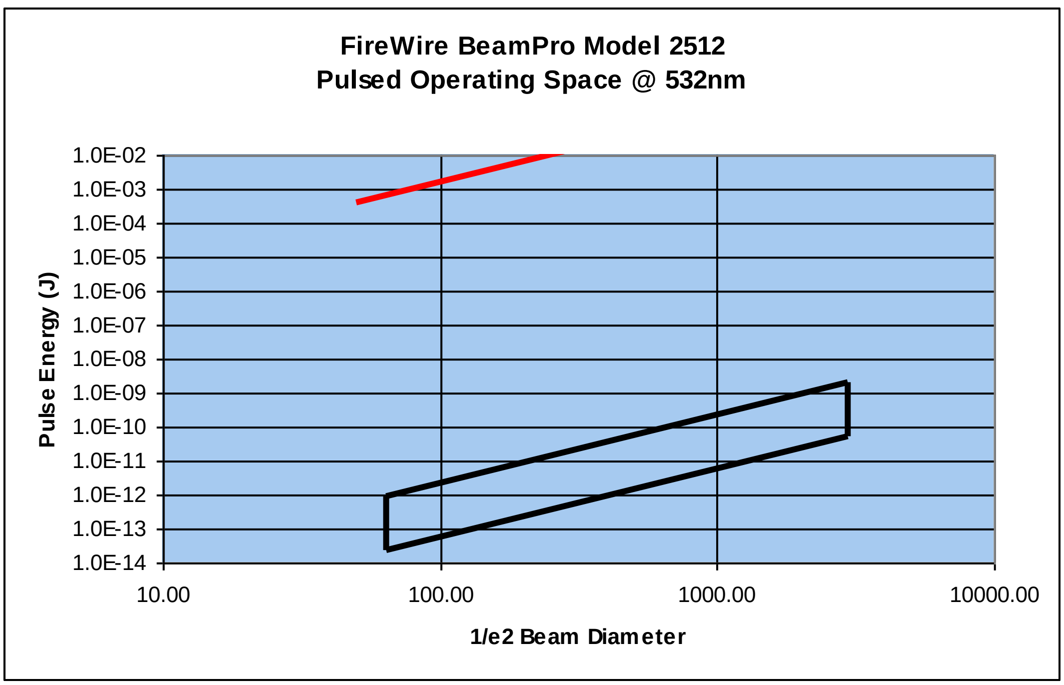


Figure 4.17. Pulsed Operating Space Chart for the CCD camera at 532nm.

4.8.3. CCD Camera Responsivity

The CCD camera responsivity curve is shown in Figure 4.18. The responsivity at a given wavelength can be used to scale the Operating Space charts for use at wavelengths other than 532nm. The shaded area below 400nm is an approximation.

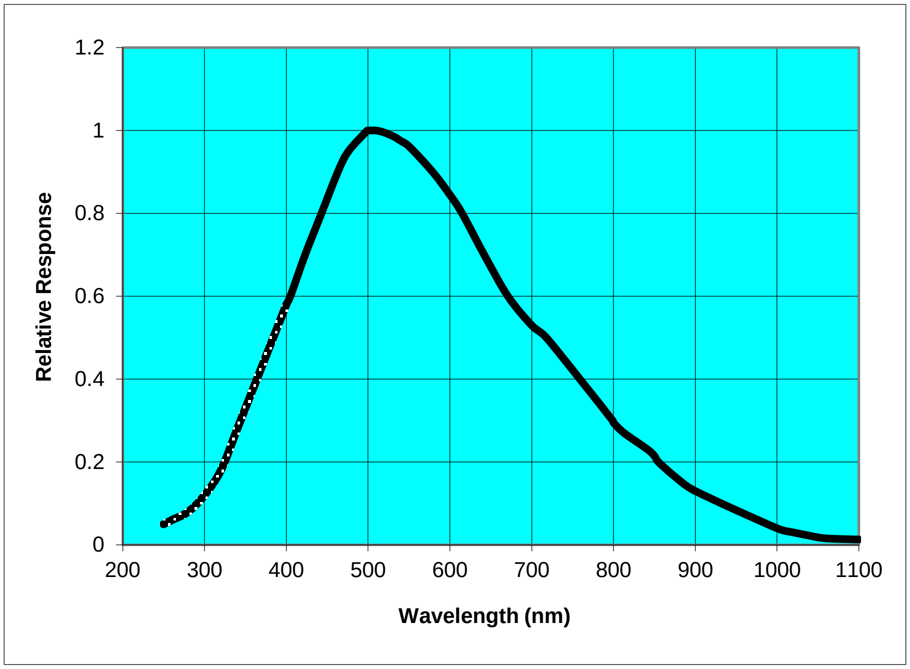


Figure 4.18. CCD Camera Spectral Response.

4.9. Beam Attenuation

Camera measurements of laser beam profiles ordinarily require many orders of magnitude beam attenuation. Attenuation can be provided using combinations of various means: front surface reflections, interference filters, absorbing filters, and exposure control, used in that order from the highest power levels to the lowest. Also, absorbing attenuators should generally be placed in the collimated beam space to avoid differential attenuation due to rays at different angles and hence different path lengths.

Attenuation requirements are dependent on the beam power and wavelength, the beam diameter, and whether the beam is CW or pulsed. Wavelength must be considered because the CCD responsivity or quantum efficiency is a strong function of wavelength. Single pulse beams with pulse duration less than 20µs cannot be attenuated using exposure control. Exposure control also does not work at NIR wavelengths at 1064nm, (down to ~900nm) due to penetration of the photons into the camera readout circuitry that severely distorts the beam image. Absorbing filters cannot be used above certain power levels as thermal lensing occurs that distorts the beam. Interference filters typically have a damage threshold at ~1MW/cm^2, or ~5-20J/cm^2. All these factors must be considered when determining a proper beam attenuation scheme.

The standard ModeScan 1780 comes equipped with a single OD 2.8 absorbing glass filter, mounted in a C-mount ring that is attached at the entrance to the optics enclosure.

(For UV wavelengths this attenuator is replaced with AR coated Inconel filters.) The internal fused silica beam splitters reflect 4% at each surface, which is equivalent to OD 1.4. The CCD camera exposure range from 20µs–27.64ms provides additional effective attenuation factor up to 1382 times, equivalent to OD 3.14. This gives a total attenuation up to OD 7.34, for beams at say 532nm, but only OD 4.2 for beams at 1064nm. In any case, it is likely for most high power lasers today that additional beam attenuation will be required. To reduce distortion, any additional beam attenuation should be added to the collimated laser beam space, i.e. in front of the test lens. Attenuators can be attached to the Iris Entrance Aperture or to the lens barrel on extension tubes using C-mount adapters. Figure 4.19 shows the Spiricon ATP-K Variable Attenuator mounted to the Iris Entrance Aperture.

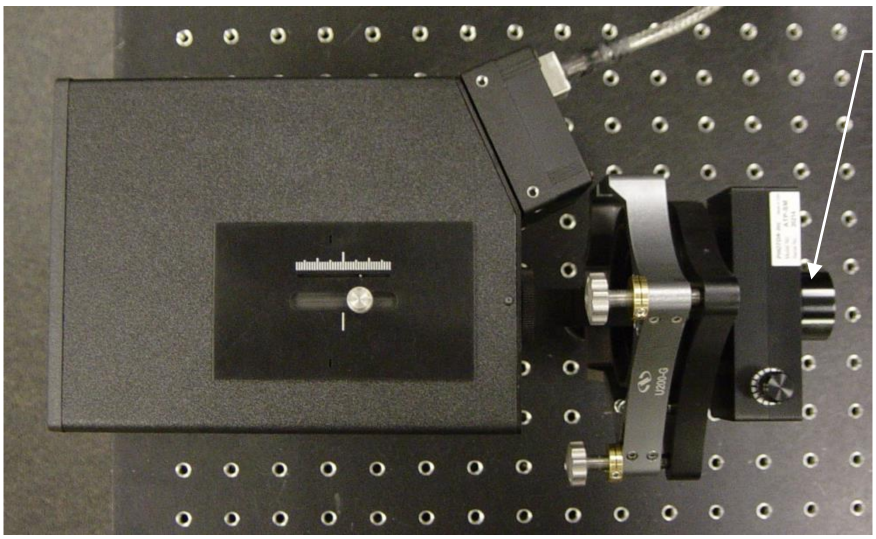


Figure 4.19. ATP-K Variable Attenuator attached to the Iris Entrance Aperture.

Prior to placement of the ModeScan in any laser beam, the beam should be properly attenuated if necessary to avoid damage to the system. Generally it is safe to expose the unit to average power levels in the range of several mW. For lasers in the tens of Watts range, it will be necessary to attenuate the beam considerably, with appropriate attenuation for the intermediate power levels.

Finally, as a general rule of thumb, use front surface reflections to attenuate the highest power beams down to levels where interference filters can be used. Use interference filters down to the levels where absorbing filters can be used, and absorbing filters down to the levels where exposure can be used.

4.10.Optical Alignment

Alignment of the ModeScan 1780 to the laser beam under test is very straightforward. The alignment involves 4 main steps;

1. Initial Placement of the ModeScan 1780 in the laser beam path

2. Coarse Alignment
3. Fine alignment of the laser beam, and
4. Fine alignment of the ModeScan 1780.

The alignment procedure is greatly simplified if there is a minimum of 2 turning mirrors and/or front surface reflectors to facilitate beam steering. The system is aligned when the 10 spots fall into the 10 sub regions of the CCD array, as shown above in Figure 4.12, or below in Figure 4.23.

4.10.1. Initial Placement

The Iris Entrance Aperture, shown again in Figure 4.20 defines the position of the optical axis at the 2-axis gimbal stage. Determine the propagation path of the laser under test, and the nominal beam diameter. Adjust the Iris to the nominal beam diameter. Then position the ModeScan 1780 so the laser beam is incident on the Iris pupil, with the ModeScan Enclosure aligned nominally along the beam path. Fully open the Iris Entrance Aperture.

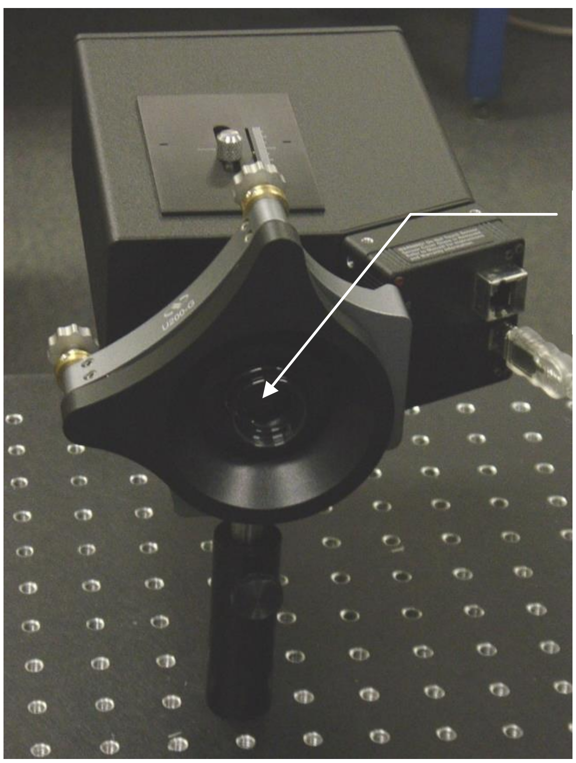
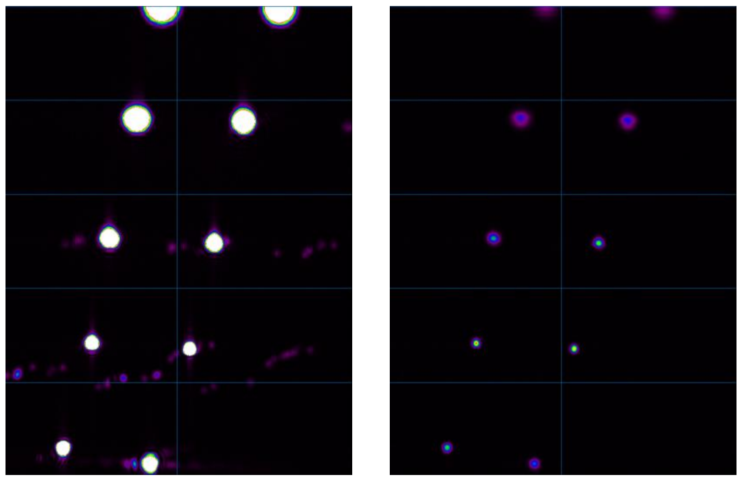


Figure 4.20. The ModeScan 1780 optical axis location at the 2-stage Gimbal Mount is the Iris Entrance Aperture.

4.10.2. Coarse Alignment

Coarse alignment is performed while observing the Video view image in the software GUI. Set the exposure to maximum so it is easy to find any grossly misaligned beams. Initial coarse alignment can be performed by rotating and/or changing the height of the ModeScan enclosure in the post mount, and also using the adjustment screws on the gimbal stage. When the system is coarsely aligned most of the 10 spots should be visible in the Video view, although their positions and focusing may not be optimal, as shown in Figure 4.21a. Use Auto Settings or manually adjust the camera exposure/gain or adjust the attenuation to obtain the image as seen in Figure 4.21b. The optimal positioning is achieved during the Fine Alignment of the laser and the ModeScan 1780.



a.) b.)

Figure 4.21. Video view showing initial coarse alignment. a.) is at increased exposure and b.) is after applying Auto Settings or making manual adjustment.

4.10.3. Fine Alignment of the Laser Beam

Alignment of the laser beam is required to correct any skew in the image of the 10 spots and also to adjust the vertical separation. This adjustment is necessary as a preliminary to properly positioning the 10 spots in their respective regions of analysis as defined by the blue grid in the Video view.

4.10.3.1. Horizontal Skew Adjustment

Horizontal skew to the left or right is the result of the laser beam being slightly off-axis in the horizontal plane. Left skew is shown in

Figure **4.22**a and right skew is shown in

Figure 4.22b. Adjust the laser pointing to the right to correct for left skew and to the left to correct for right skew, as indicated by the sketch in each figure. The video image of the 10 spots properly aligned with minimal skew is shown in

Figure 4.22c. However, the 10 spots are still not properly positioned to fall into the regions of analysis. This adjustment is made using the gimbal mount as described below in section 4.10.4.

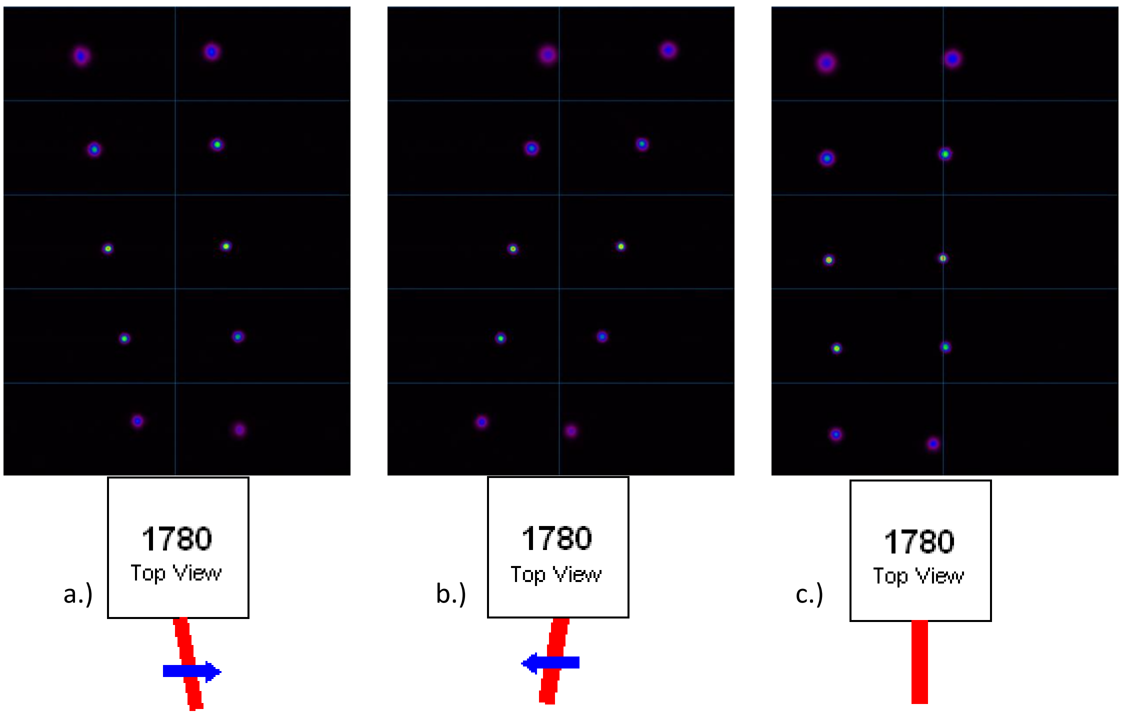


Figure 4.22. Video view showing a.) left skew misalignment, b.) right skew misalignment, and c.) proper alignment. The blue arrow indicates the direction to re-point the laser beam to correct the skew.

4.10.3.2. Vertical Separation Adjustment

Expanded or reduced vertical separation is the result of the laser beam being slightly off-axis in the vertical plane. Expanded separation is shown in Figure 4.23a and reduced separation is shown in Figure 4.23b. Adjust the laser pointing downward to correct for expanded separation and upward to correct for reduced separation, as indicated by the sketch in each figure.

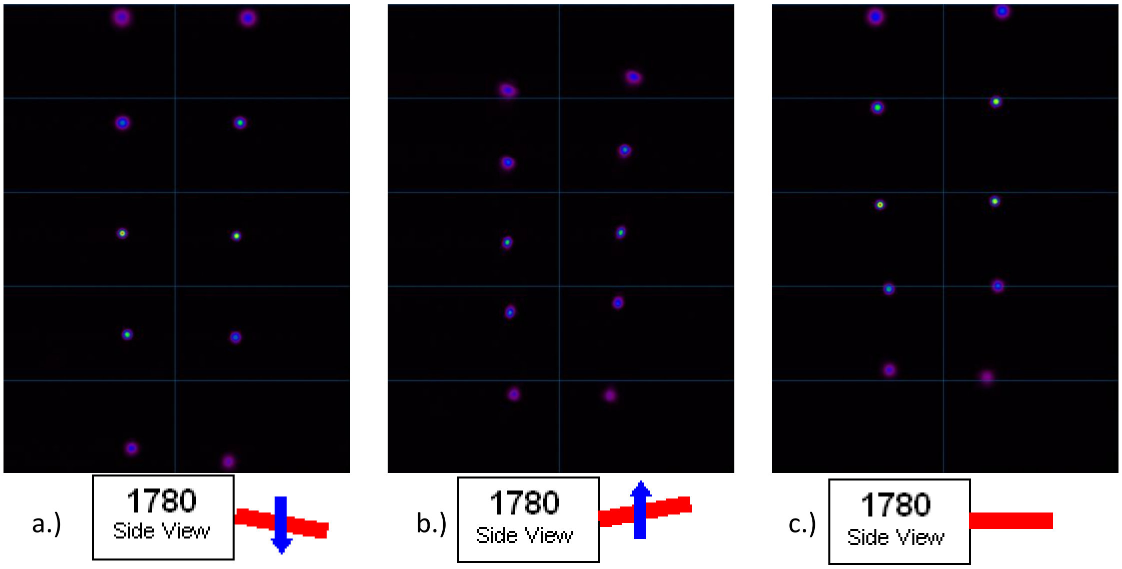


Figure 4.23. Video view showing a.) expanded vertical separation, b.) reduced vertical separation and c.) the proper separation where the spots are spaced nominally at the horizontal grid spacing. The blue arrow indicates the direction to re-point the laser beam to correct the vertical separation.

Figure 4.23c shows the video image of the 10 spots with proper vertical separation. The 10 spots are still not properly positioned to fall into the regions of analysis. This adjustment is made using the gimbal mount as described below in section 4.10.4.

4.10.4. Fine Alignment of the ModeScan 1780

After alignment of the laser beam to achieve minimal horizontal skew and proper vertical separation, it is necessary to position the 10 spots so they lie appropriately in the 10 respective regions of analysis of the CCD camera. This adjustment is made using the gimbal stage adjustment screws. If the spots are displaced horizontally, as in

Figure **4.22**c, use the horizontal adjustment screw to reposition the spots. If the spots are displaced vertically, as in Figure 4.23c, use the vertical adjustment screw. Proper alignment of the spots is shown in Figure 4.24.

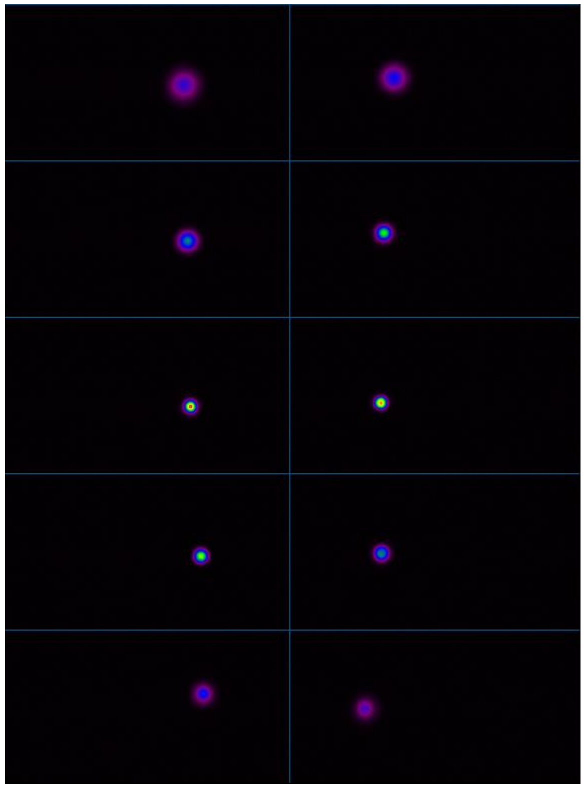


Figure 4.24. Video view showing the 10 spots properly positioned to be in the 10 respective regions of analysis of the CCD camera.

4.11.Lens Position Adjustment

While observing the Measurement view, adjust the lens position so the beam waist falls near the center of the measured beam caustic, as shown in Figure 4.25. This measurement configuration results in the best hyperbolic fit to the data, and thus reduces the error associated with the fit. It is also useful to observe the Peak M^2 Gauge during the lens adjustment to ensure proper signal levels in the 10 beams, shown in Figure 4.26. If the beam has significant astigmatism it may be necessary to measure each axis independently.

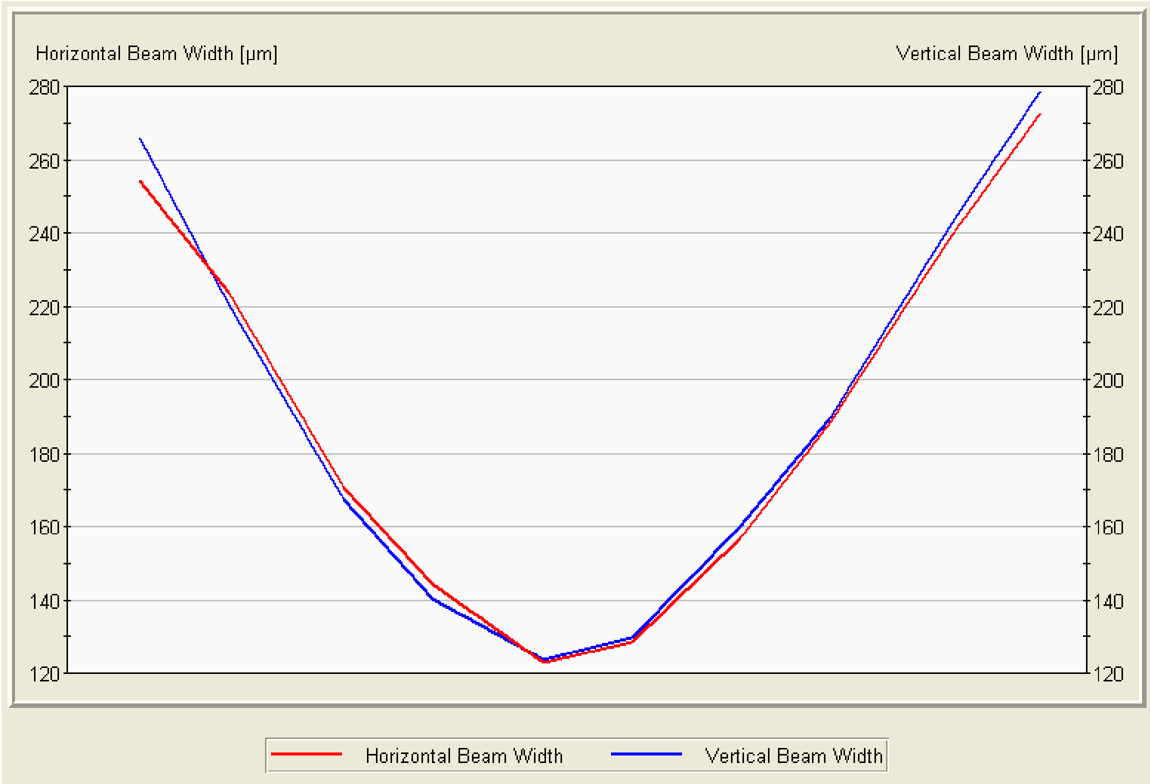


Figure 4.25. Measured beam caustics displayed in the measurement view, with beam waists near the center.

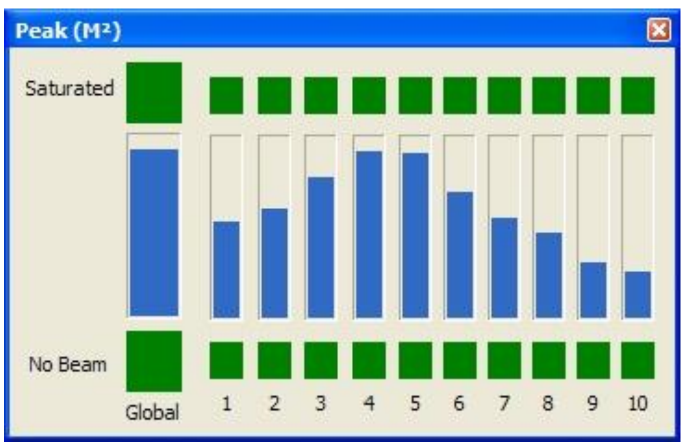


Figure 4.26. Peak M2 Gauge indicates the peak profile signal level for each of the 10 beams.

4.12.External Trigger/Asynchronous Reset

The External Trigger is an Asynchronous Reset that restarts the camera frame cycle. It is used to optimize the acquisition and measurement of pulsed laser beams. External trigger is applied to the 10-Pin RJ-45 Jack on the camera; pin 5 is the trigger and pin 6 is ground). An External Trigger Cable is supplied with BNC connector at one end and the RJ-45 Jack connector at the other. The external trigger signal requirement is 5V ±1V @ 10mA ±5mA (Positive transition). The timing requirements for external trigger are shown in Figure 4.26. The trigger rising edge must precede the laser pulse by nominally 32μs.

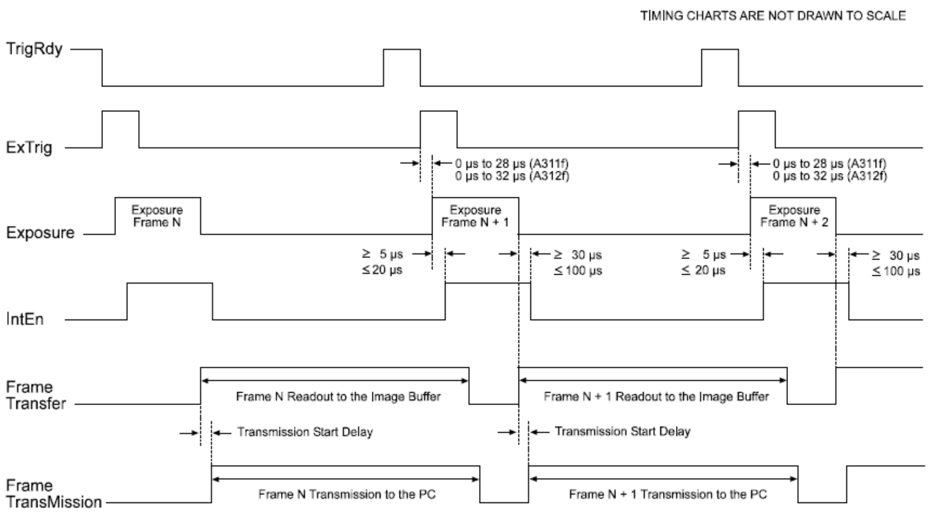


Figure 4.27. External trigger Timing Requirements

4.13.Calibrate the System

It is necessary to perform a calibration prior to making beam measurements to obtain the specified accuracy. It is also necessary to recalibrate every time something is changed, such as exposure or gain.

There are 2 visual indicators in the GUI, which change depending on the system calibration status. These indicators are the Calibration icon on the main toolbar and the status bar. 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 gain and exposure, trigger mode, and unit serial number.

The status bar changes color to indicate the status of calibration. **RED** indicates an uncalibrated system, YELLOW indicates that the system has been calibrated, but that something about the measurement configuration has changed; either the exposure or gain, the trigger mode, or the unit serial number. In this case it is recommended to recalibrate. If the status bar has the default color, the system is calibrated under the current measurement configuration.

To calibrate, use the displayed Calibrate icon, 

on the 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. The Camera calibration dialog reports the date and time of the last calibration.

5. Acquisition and Analysis Software

The ModeScan 1780 operates under the FireWire BeamPro Acquisition and Analysis Software. The FireWire BeamPro Software was written specifically for Microsoft Windows XP Professional or Microsoft Windows 2000 Professional and takes full advantage of the menu driven, multi-windowing environment. The software provides quantitative measurement of numerous beam spatial characteristics in accordance with the ISO 13694 standard and M^2 parameters according to the ISO 11146 standard.

The software operates in 2 modes: the M^2 **Beam Propagation** mode and the **Standard** Beam Profiling mode. The M^2 Beam Propagation mode includes a Live Video window for displaying the 10 beam spots, a Measurement view showing the beam caustics, and the Beam Statistics view, a tabular summary for the M^2 parameters and beam diameters with Pass/Fail analysis. Time Statistics views with strip chart time displays and summary statistics and overlays are also available, and a Notes view for entering text. In the standard mode, all the features for beam analysis are available for closer inspection of a single beam. Additional views available are the Profile, 2D Contour, and 3D Profile.

For data display and visualization, the user can arrange and size these multiple windows as required. These may contain, for example as shown below in Figure 4.10, the Video, Measurement, and Beam Parameters views. Such custom-configured instrument screens with multiple views can be saved as configuration files for repeated use.

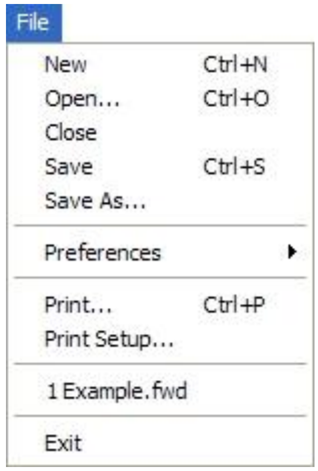
Data can be saved as program files, or exported to spreadsheets, math and statistical analysis programs and process/ instrumentation control programs by logging to files or COM ports, or by sharing using ActiveX Automation.

5.1. Program Menus

5.1.1. 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, and 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:

***.fwd**

Data File: Includes screen configuration and associated image and computed data. Only the FireWire BeamPro Acquisition and Analysis Software can use this file.

***.fwc**

Configuration File: Includes screen configuration only. Only the FireWire BeamPro 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 short (16-bit unsigned). The pixels are saved line by line, starting with the top line. This file cannot be read back by FireWire BeamPro Acquisition and Analysis Software.

***.tif**

Frame Data – TIFF File. Saves the current frame (raw image) as uncompressed 16-Bit TIFF image.

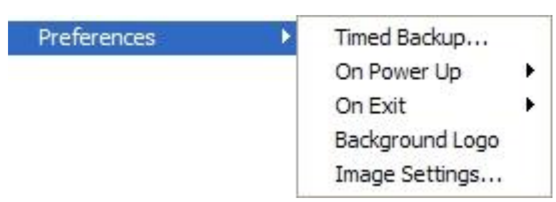
***.asc**

ASCII File. Saves data displayed in all open views in ASCII format.

IMAGE

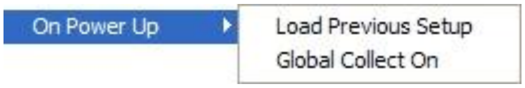
Saves the program screen as an IMAGE file, either BMP, JPEG, GIF, TIFF, or PNG File. This is used for exporting graphics into documents and reports. The IMAGE file format is selected under **Image Settings** dialog in the **File** menu **Preferences** item.

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 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.

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.

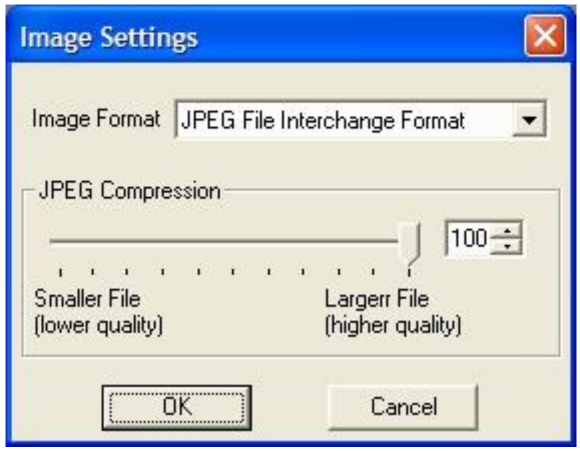
Prompt — When checked, the user is prompted with an **Leaving Already?** dialog upon exit.

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

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.



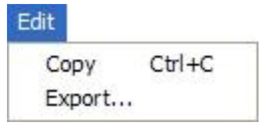
Print… Prints a picture of all open windows to the currently selected default printer. The user may change this printer from the **Print** dialog if desired.

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

Exit Exits the program.

5.1.2. Edit Menu

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

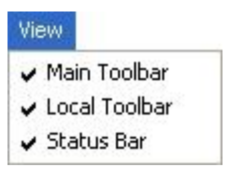


Copy — Copies the current window to the Windows clipboard as a bitmap image and/or text, depending on the active view. From there, the information can be pasted into other program applications.

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.

5.1.3. 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.

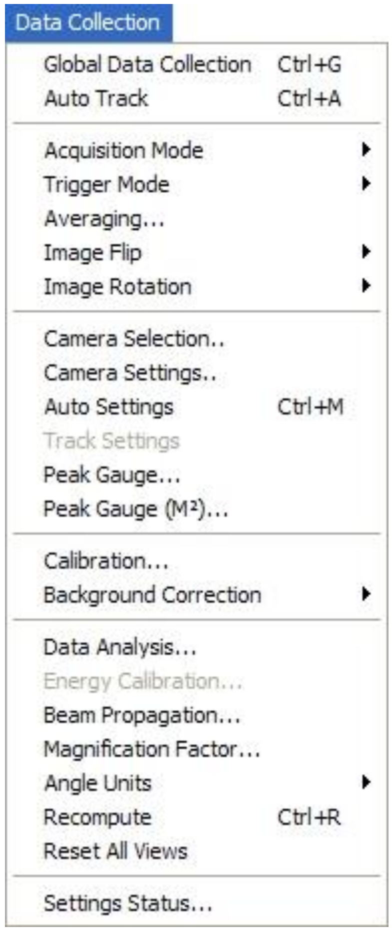
Status Bar — When checked, the status bar at the bottom of the main window is visible.

5.1.4. 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.

5.1.5. 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 auto tracking 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 the acquisition mode:

Choices are:

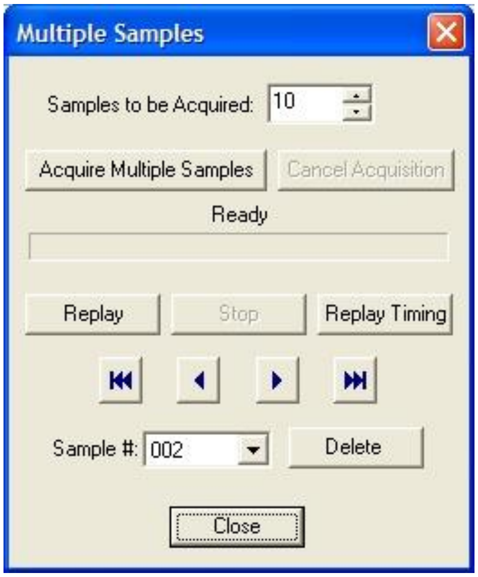
Laser Positioning Captures and displays images in the Video window. No calculations are performed, thus providing the fastest update rate. This mode is intended for setup prior to acquiring quantitative data. Use this mode for positioning your laser in the sensor aperture, adjusting attenuation, or for visually tuning the laser.

Analysis Enables data analysis computations.

Single Shot Enables single shot acquisition and analysis. One frame is acquired and processed each time the user selects the Global Data Collection in the Data Collection menu or, alternatively, after clicking the Global Data Collection icon on the toolbar.

Multiple Samples… Enables the multiple samples acquisition mode. Sequential samples are acquired and stored for later playback and analysis.

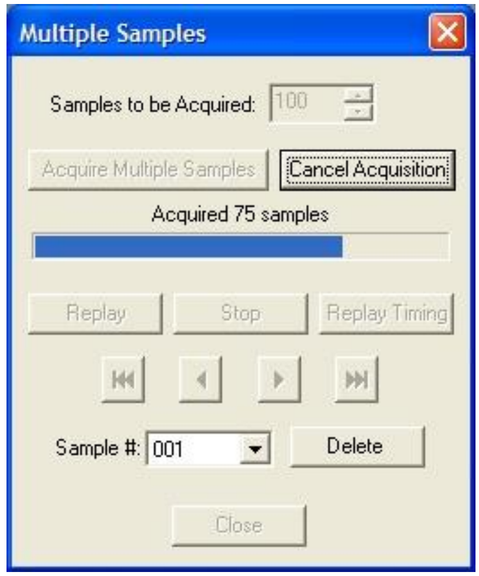
The maximum number of samples cannot exceed 512 and depends on the video format and the available space on the hard drive.



Samples to be Acquired Select the desired number of samples to be acquired in the edit box (or by using the attached spin control).

Acquire Multiple Samples

Start the sequential acquisition. During the acquisition process the progress bar will indicate how many frames were already acquired. Once the acquisition process is done, the software will return full control to the user.



Cancel Acquisition

Cancels the multiple acquisition process and return full control of the software to the user. All the samples already acquired will be available for display and analysis.

Replay

Replay the acquired samples. The sample number from where the replay begins can be selected by entering this number in the Sample # dialog box. All the BeamPro analysis features are available in the replay mode.

Stop

Stop the replay sequence.

Replay Timing

Opens a dialog box for selecting the replay update rate.

First: displays the first acquired sample in the sequence.

Previous: displays the previous sample in the sequence.

Next: displays the next sample in the sequence.

Last: displays the last acquired sample in the sequence.

Sample # Enter the sample number to be displayed, deleted or used as start for replay.

Delete Deletes the sample selected in the Sample # dialog box. When a sample is deleted, all other samples keep their initial index value.

Close Close the Acquire Multiple Samples dialog box.

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. This option is available only in the Standard mode.

External Captures and displays images whenever an external trigger pulse is applied. The External trigger pulse acts as an Asynchronous Reset, and must be applied before the laser pulse, i.e., a pretrigger. Use this mode when measuring **pulsed lasers** where external pre-triggering is available. This is the best mode for your **pulsed laser.**

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.

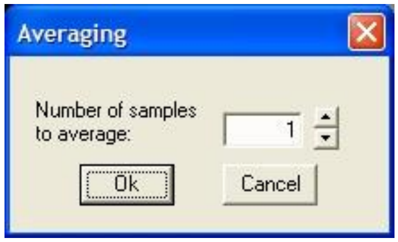


Image Flip

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.

These options are available only in the Standard mode; in the Beam Propagation mode the Image Flip is set by default to Vertical.

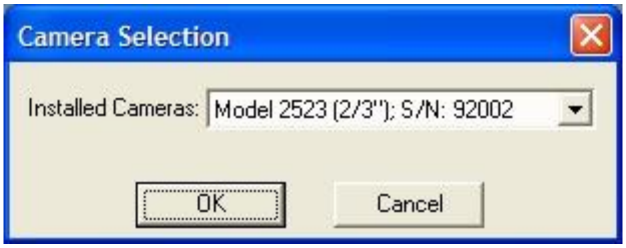
Image Rotation

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.

These options are available only in the Standard mode; in the Beam Propagation mode the Image Rotation is set by default to 90°.

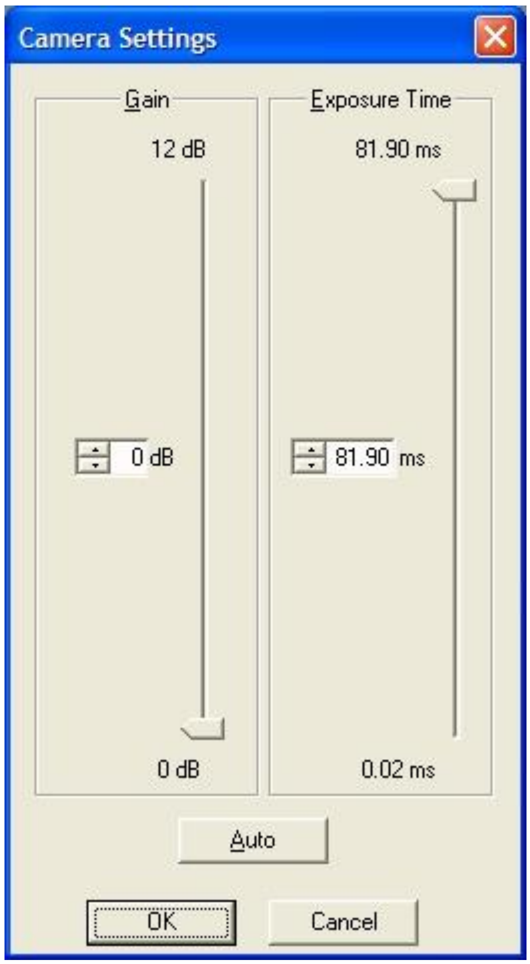
Camera Selection…

Opens the **Camera Selection** dialog for selecting FireWire BeamPro cameras for use by Model and Serial Number. When a new camera is selected the system will not be calibrated and the data collection would be turned off.



Camera Settings…

Opens the **Camera Settings** dialog for setting the camera **Gain** and **Exposure Time**. The Gain ranges from 0 to 12 dB for Models 2512 and 2523 and from 0 to 7 dB for Model 2518, while the exposure ranges between 20µs and 81.9ms for Models 2518 and 2523 and between 20µs and 27.52ms for Model 2512. The gain increment is 1dB, while the exposure increment is 0.02ms (20µs). The selected gain and exposure time are displayed on the edit box placed on the left side of the corresponding slider.



Auto

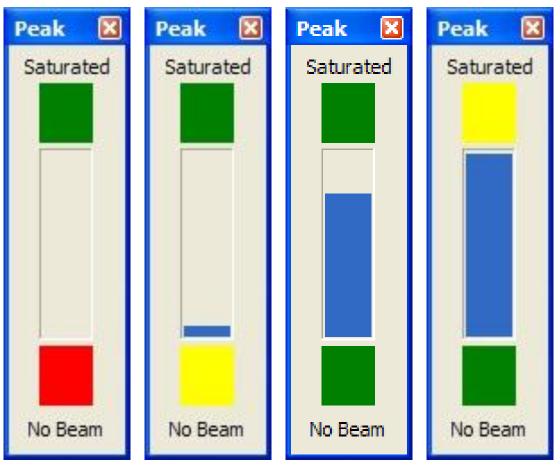
Initiates a one-shot automatic setting of exposure and gain. The target amplitude is 90-95% full scale. Exposure is adjusted first and then gain.

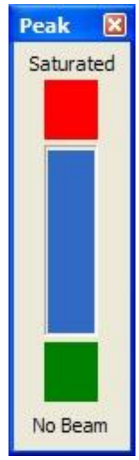
Auto Settings

Initiates a one-shot automatic setting of exposure and gain. The target amplitude is 90-95% full scale. Exposure is adjusted first and then gain.

Track Settings Enables continuous automatic setting of exposure and gain to maintain peak amplitude at 90-95% full scale. This option is currently unavailable.

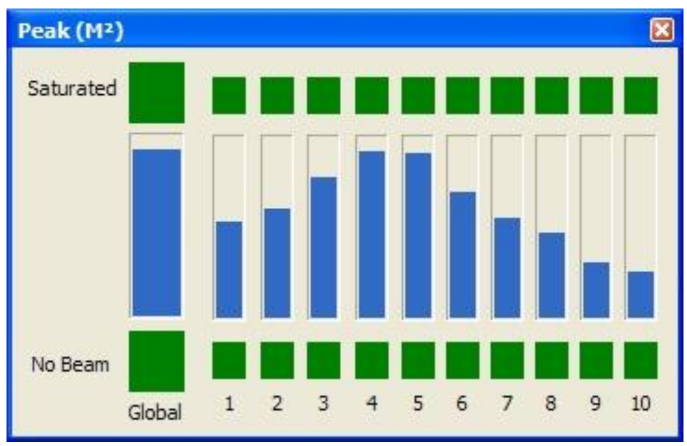
Peak Gauge… Opens the Peak dialog, showing the status of the peak signal amplitude of the beam profile in the entire camera frame. All 5 conditions of the dialog are shown below. The dialog includes a level indicator and uses colorization to display status near saturation and "no beam" conditions. The "No Beam" condition corresponds to a level below 32 counts, and is indicated by "red" in the box at the bottom. Above 32 counts the box changes in color to yellow, and stays yellow up to 400 counts, at which point it changes to "green". (400 counts is the minimum amplitude at which the beam diameter accuracy is within the specification of ±2% for a 64μm beam.) For saturation, the top box is green if the amplitude is below 4000 counts, changing to "yellow" above 4000 counts and to "red" at 4095 counts. The blue level indicator is a linear display of the signal amplitude from 0-4095 counts. Generally, for a good measurement the color indicators should be all green.





Peak Gauge (M^2)…

Opens the Peak (M^2) dialog for the Beam Propagation M^2 mode, shown below. This dialog includes peak signal amplitude indicators for each of the 10 beams in the camera frame, and one summary indicator for the entire frame. Operation is described above for the Peak Gauge. Generally, for a good M^2 measurement the color indicators should be all green.



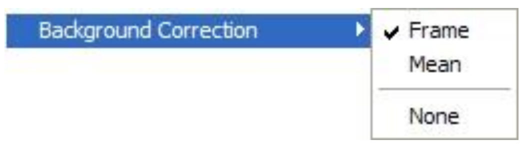
Calibration…

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.

Mean

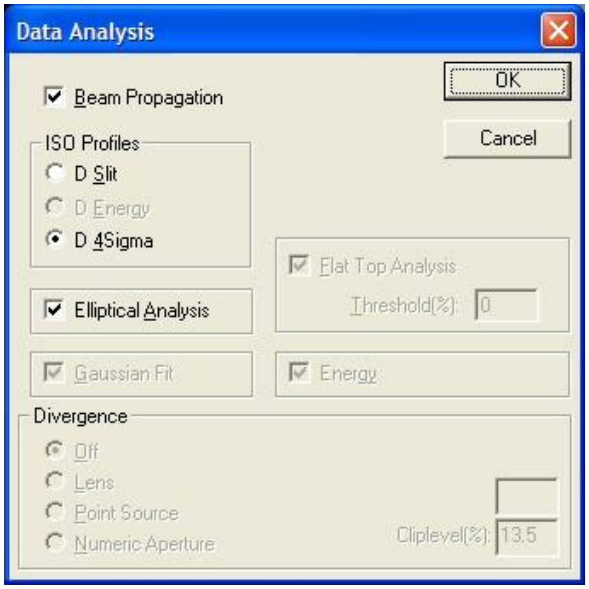
Selects the background mean value correction method. The mean value of the background frame is subtracted from each pixel value in the data frame.

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:

Beam Propagation Selects the Beam Propagation Analysis mode, available only with the ModeScan Model 1780 system, for simultaneous analysis of 10 beam profiles sampled along the beam propagation caustic.

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. This option is available only in the Standard mode.

D 4sigma Selects the second moment method for determining beam widths. The computation determines the second moment of the laser beam distribution.

Elliptical Analysis 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.

Gaussian Fit: 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. This option is available only in the Standard mode.

Flat Top Analysis Enables **Uniformity** or **Flat Top Analysis** of Energy Region of Interest (ROI). The Energy ROI is a user-defined region in the **Video** window. This option is available only in the Standard mode.

Threshold (%) 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.

Energy When selected, the total energy or power in the Beam Area is computed. 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. This option is available only in the Standard mode.

Divergence

Selects the method for divergence computation. This option is available only in the Standard mode.

Choose from 1 of 4 possible selections:

Off

No divergence computations will be made

Lens

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

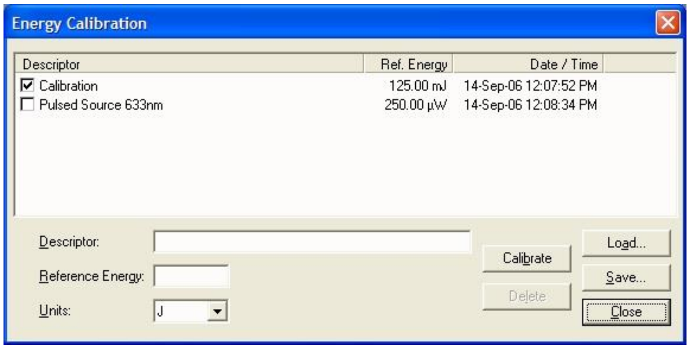
Selects the **Point Source** method for computing divergence. When selected, the distance from the point source to the measurement plane, in millimeters, and the beam width clip level percentage must be specified.

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 ($\sin(\theta/2)$).

Energy Calibration…

Opens the **Energy Calibration** dialog for entering calibration reference records and for selecting the calibration reference record for use. When the first calibration file has been added, it will display as the default and the box will be checked. With multiple calibrations, set the default calibration by checking the desired checkbox. The listed records will be saved with the FireWire BeamPro data file if it is saved. The records can also be saved as separate calibration record files using the Save feature described below.



This option is available only in the Standard mode.

Descriptor — *Text Field for entering Calibration information. Maximum 256 characters.*

Reference Energy — *Numeric Field for entering the Calibration Reference Energy/Power obtained from independent measurements of the beam with an energy or power meter. Values between 1 and 1000 are allowed. Units are selected in the Units Combo Box.*

Units — *Combo Box for setting the units of Energy/Power. Units range from J to pJ or W to pW.*

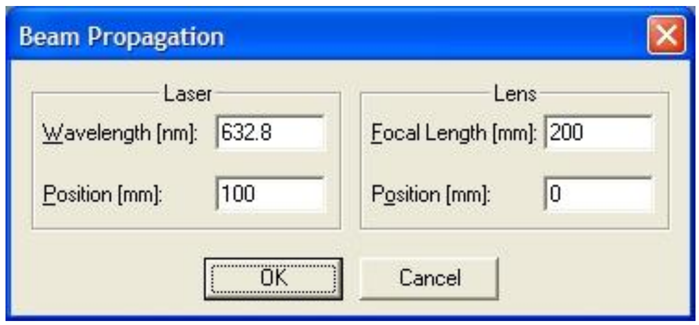
Calibrate — *Initiates the Calibration Procedure. At least one of the calibration text fields must be different from the previous calibration. There should be a calibration for each type of laser to be measured. The power meter is a relative meter and must be calibrated to a known source for each wavelength and power range to be measured.*

Delete *Deletes the selected Calibration.*

Load… *Opens a dialog for selecting files containing calibration reference records. When the file is loaded all previously listed records in the Energy Calibration Dialog are deleted.*

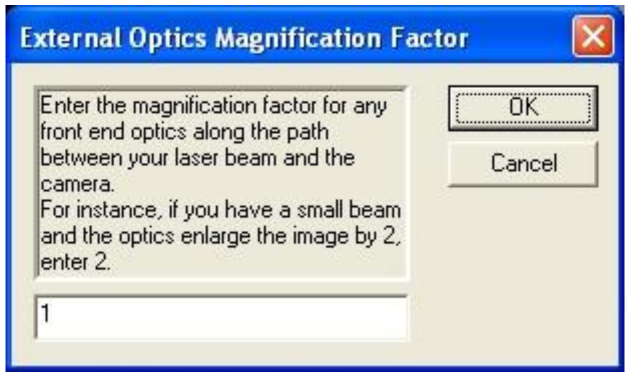
Save… *Opens a dialog for selecting the name and path for the file that contains calibration reference records.*

Beam Propagation… *Opens a dialog box for entering the parameters for M² measurement using the Model 1780 ModeScan. The Wavelength is required for the computation of M² ; and the Laser Position, Lens Focal Length, and Lens Position are required for reporting the ISO M² parameters in the space of the laser under test.*



This option is available only in the Beam Propagation mode.

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.

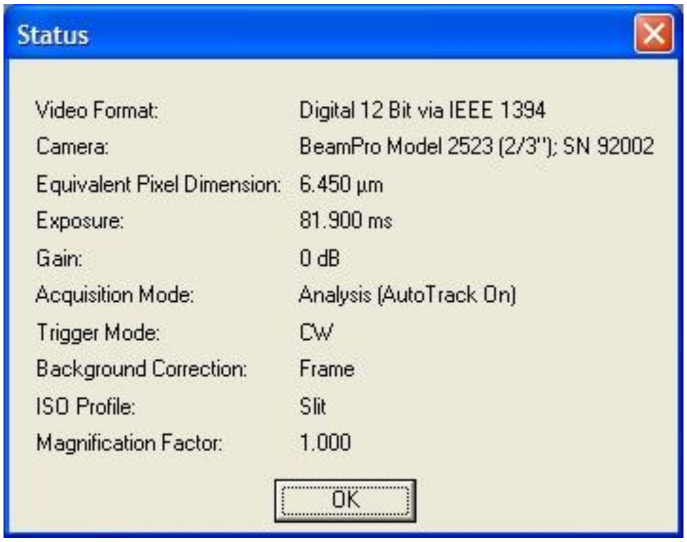


Angle Units Opens a menu for selecting the units used for reporting all the angles, either milliradians or degrees.

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

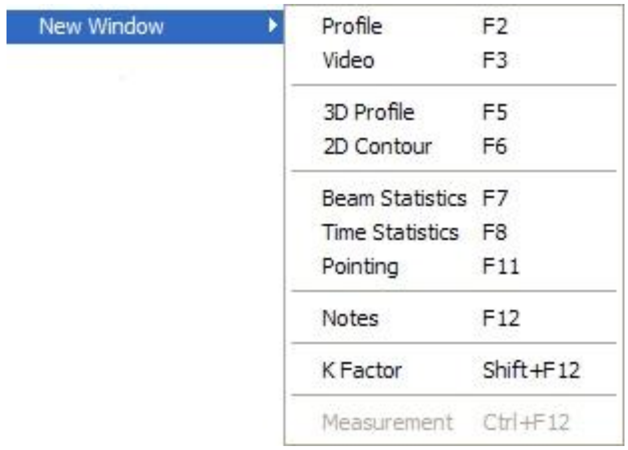


5.1.6. Window Menu

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.

5.1.7. Help Menu

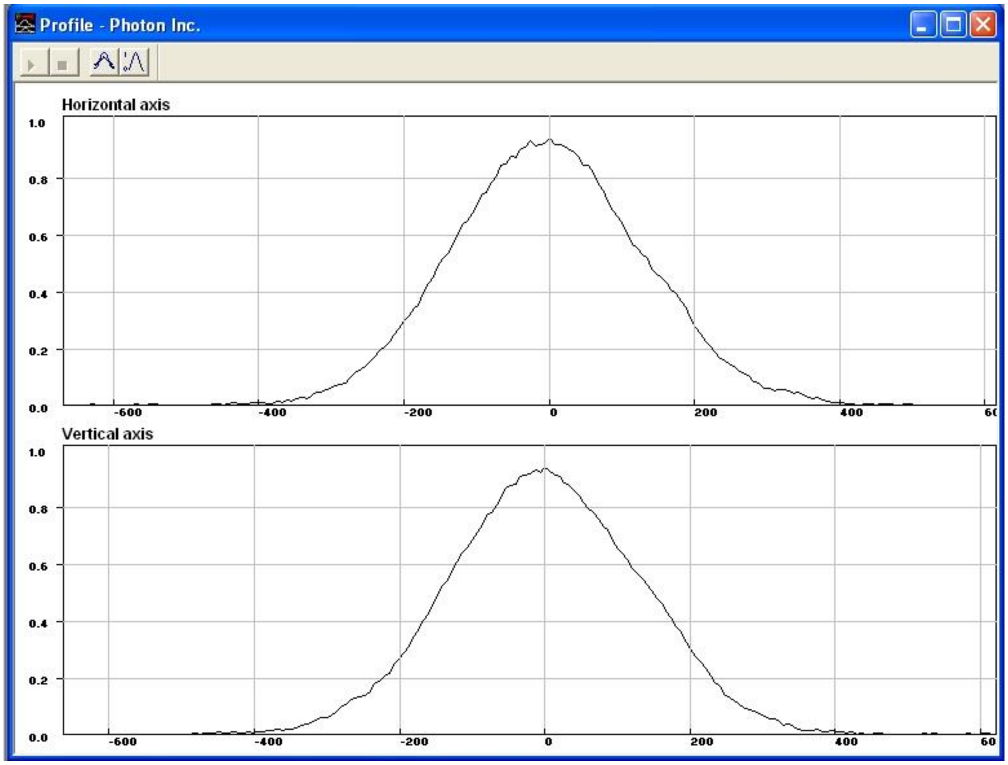
Use the **Help** menu to access **Help Topics**, and the **About FireWire BeamPro** dialog box. Help Topics are currently unavailable.

5.2. Window Descriptions

5.2.1. Profile

The **Profile** window displays either Pinhole or equivalent Slit profiles in orthogonal directions along the crosshairs displayed in the live **Video** window.

The **Profile** window is available only in the Standard mode.



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.

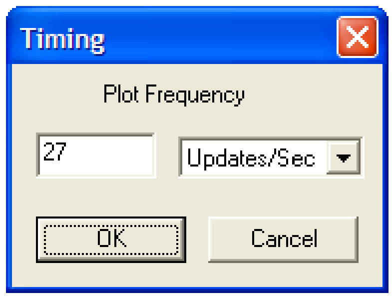
For Slit profiles the crosshairs identify the direction of the equivalent slit scan.

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.

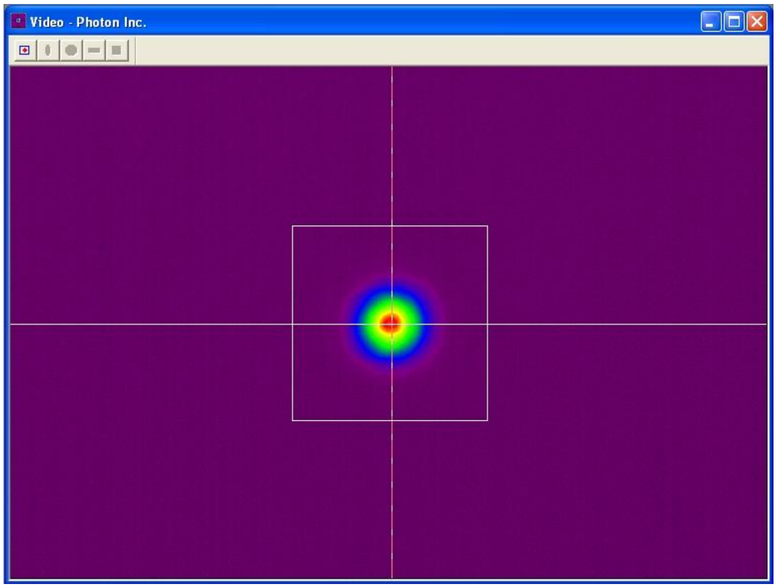
 Turns Gaussian Fit overlay on/off.

 Turns Normalization on/off.

5.2.2. Video

The **Video** window depends on the operating mode.

In the **Standard** mode the **Video** window displays the video laser image. An example of the **Video** window in the Standard mode is given below.

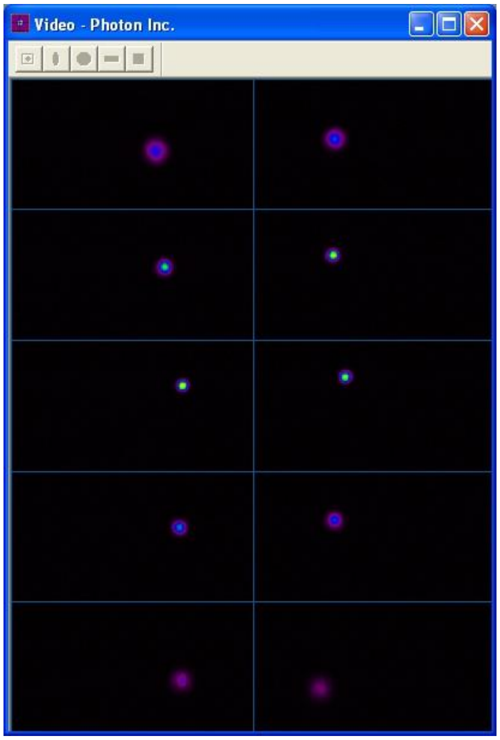


The crosshairs in the image identify the location and/or direction of profiles displayed in the **Profile** window, depending on the type of profile selected, either **Pinhole** or **Slit**, in the Profile options. If data analysis is set to the default XY mode, then the profile axes are horizontal and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

In the **Beam Propagation** mode the **Video** window displays the 10 beams in the 10 regions of analysis as defined by the blue grid. An example of the **Video** window in the Beam Propagation mode is given below.



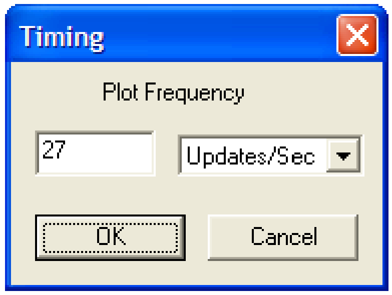
The **Options** menu available when the **Video** window is active in the Standard mode is shown below. (In the Beam Propagation mode, selections under Overlays, Set Beam Area and Set Energy ROI are unavailable.)

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…

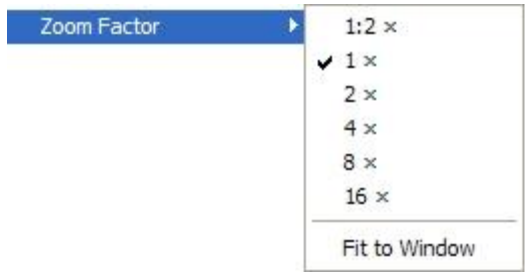
Opens a dialog box for selection of the display color scheme. Choices available are: Rainbow, Gray, Red, Green and Blue.

View Finder

Opens a display box that shows the entire camera video image.

Zoom Factor

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



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.

Off Turns the cross hair overlay off.

Centroid Places the cross hairs at the centroid.

Peak Places the cross hairs at the peak.

*User Define*d 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.

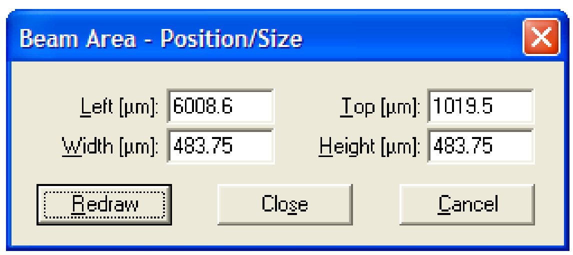
Set Beam Area — Allows the user to set a Beam Area manually.

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** again 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: Click on **Set Beam Area** In the **Beam Area–Position/Size** dialog box, enter the Top, Left, Width, and Height coordinates in the designated edit boxes.



Redraw — Redraws the beam area based on the new coordinates and keep the **Beam Area-Position/Size** dialog box open.

Close — Closes the dialog box.

Cancel — 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 (from Data Collection menu, Data Analysis dialog) must be enabled for the 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.

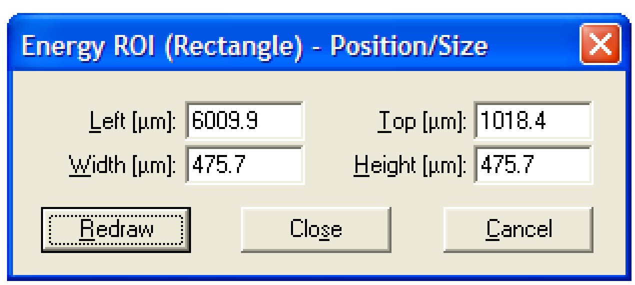
Note: Selecting the one of the **Set Energy ROI** item will also open (or close) the corresponding **Energy ROI – Position/Size** dialog box.

To set Energy ROI using coordinates:

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 enter coordinates:

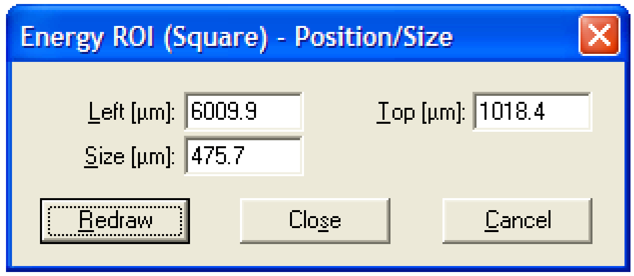
Rectangle:

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

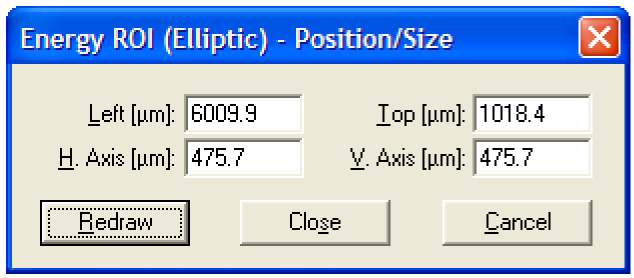


Square:

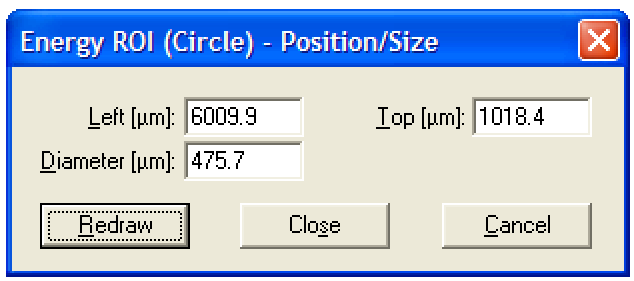
Enter the **Left**, **Top** coordinates and the **Size** for the Square Energy ROI.



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



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



Redraw Redraws the energy ROI 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.

Record (AVI) Turns the video record mode on or off, for recording live video sequences of laser beam profile images. When turned on a Save As dialog appears for entering the name of the AVI file. The maximum number of frames that can be stored in a file is 512. The AVI files cannot be played back in the software.

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

 Set Beam Area

 Energy ROI: Elliptical

 Energy ROI: Circular

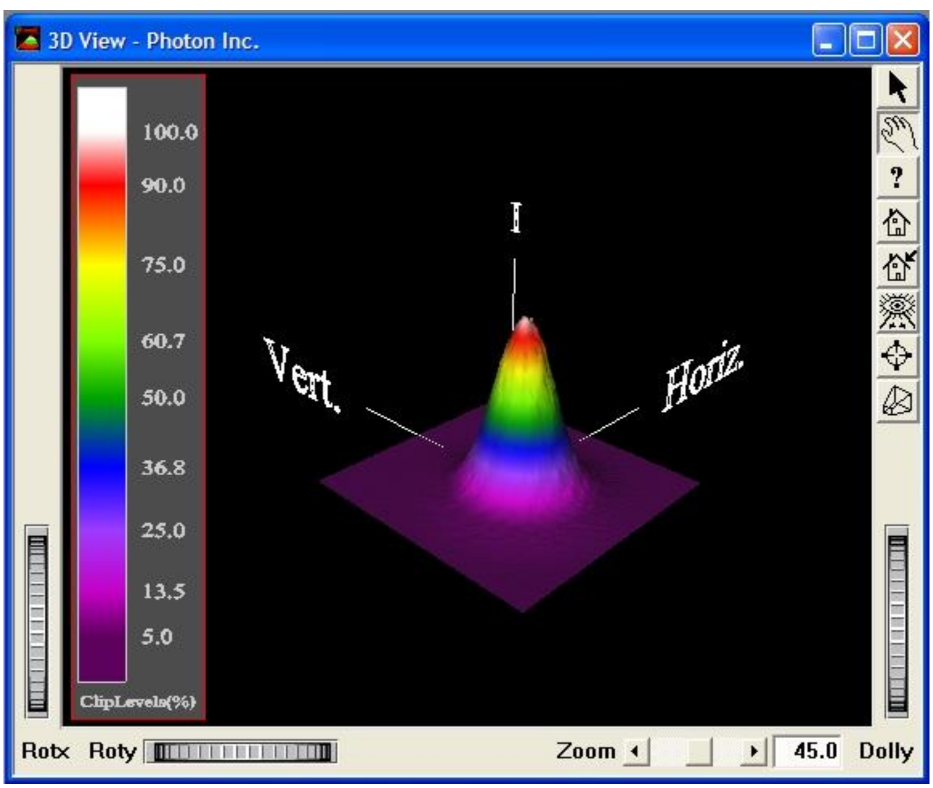
 Energy ROI: Rectangular

 Energy ROI: Square

5.2.3. 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 **3D Profile** window is available only in the Standard mode.

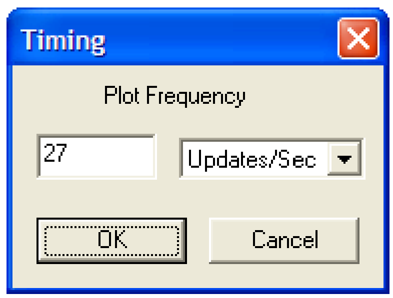


The **Options** menu available when the **3D Profile** window is active is shown below.

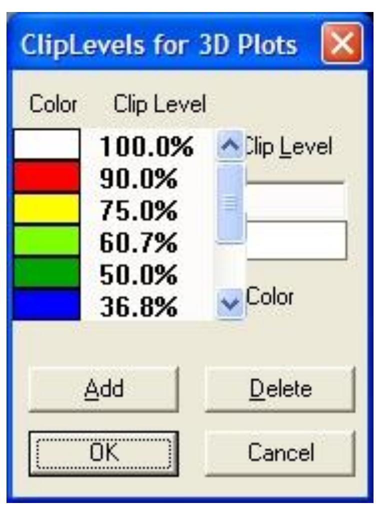
The selections are:

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.



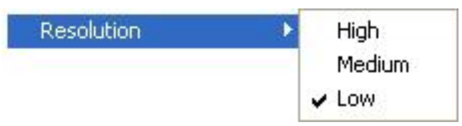
This option is not available for data displayed using the logarithmic scale. In this case, the contour levels are fixed at the 0, -3, -5, -10, -13, -20, -23, -30, and the -33 dB levels.

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**, and **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.

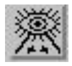

Chooses the **Hand** cursor, which allows image manipulation using the mouse directly in the image or by using the thumbwheel controls. (When the mouse is moved to the window border the **Hand** cursor changes to the **Arrow** cursor).


This **Help** menu is inactive.

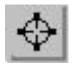

Resets the view to a preset **Home** default

position, size and orientation.

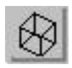
Sets the default settings for the **Home** button.



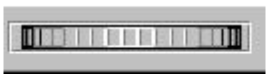
Restores the view to include the entire image.



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.

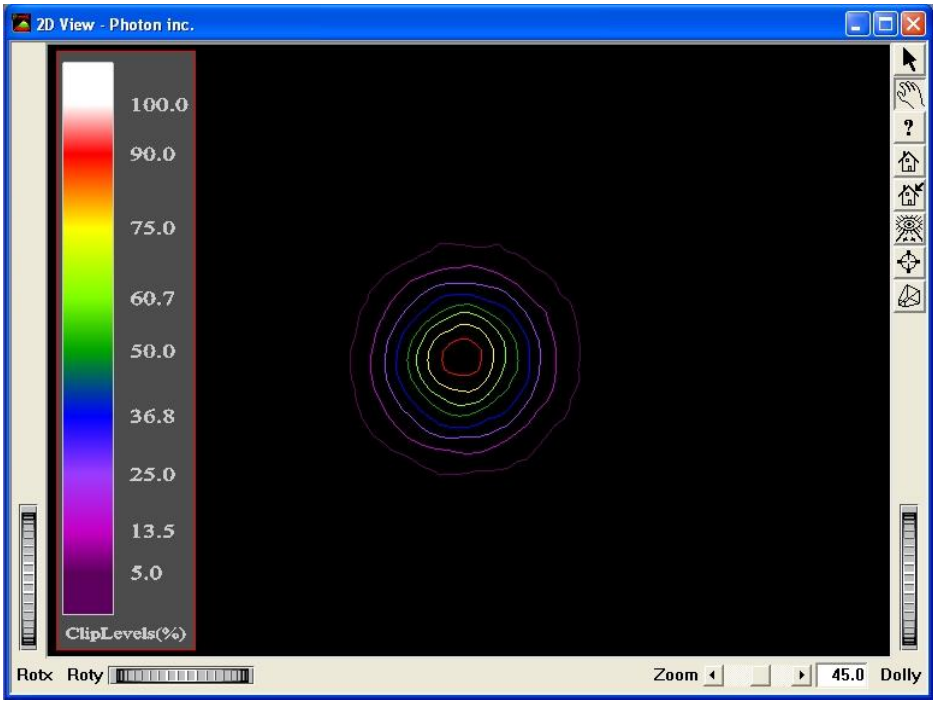
Zoom

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.

5.2.4. 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 **2D Contour** window is available only in the Standard mode.

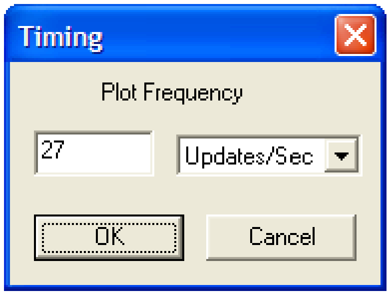


The **Options** menu available when the **2D Contour** window is active is shown below.

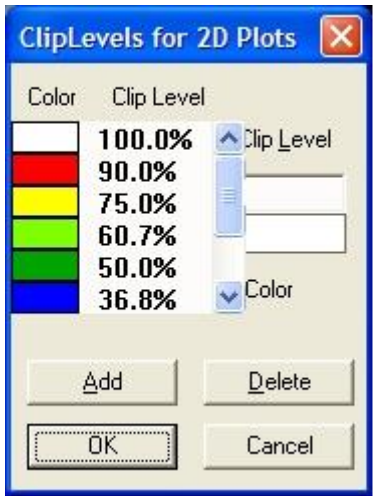
The selections are:

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**, and **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.

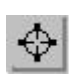
 Chooses the **Hand** cursor, which allows image manipulation using the mouse directly in the image or by using the thumbwheel controls. (When the mouse is moved to the window border the **Hand** cursor changes to the **Arrow** cursor).

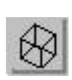
 This **Help** menu is inactive.

 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

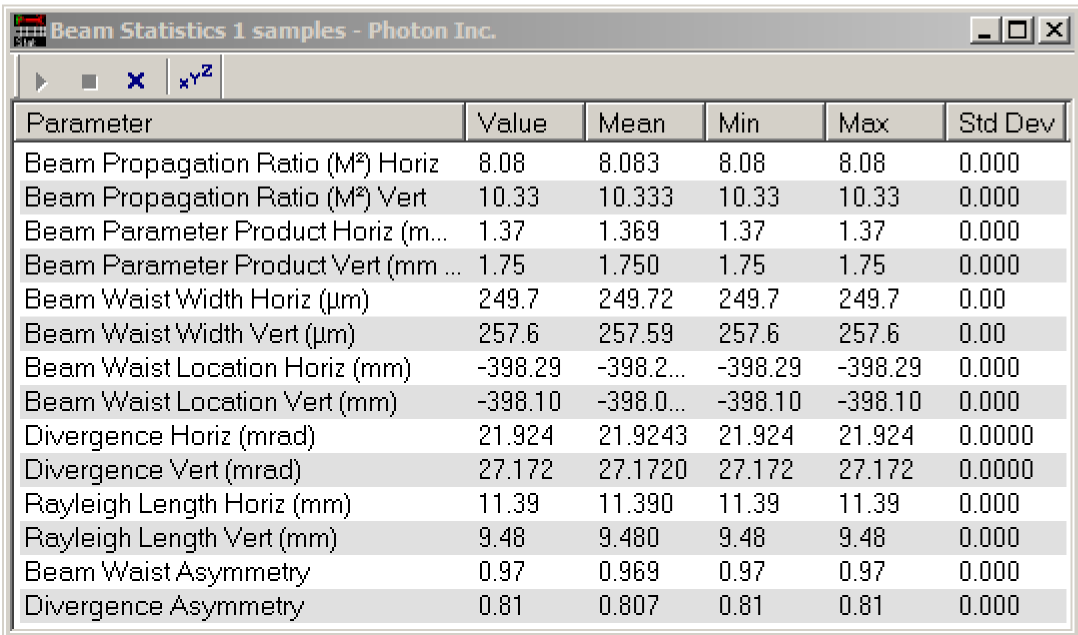
The method for zooming the image depends on the type of display projection selected. In the Perspective projection mode, use either the zoom control scroll bar at the bottom of the window, or use the **Dolly** thumbwheel at the lower right border of the window. In the **Orthographic** projection mode, 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.

5.2.5. 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.

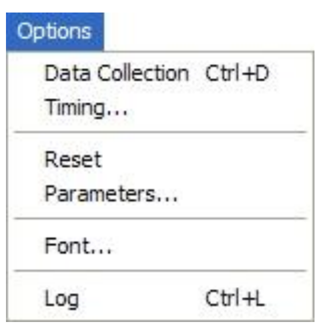
The parameter selections depend on the software operating mode, either **Standard** mode or **Beam Propagation** mode.

5.2.5.1. Beam Statistics for M^2 Beam Propagation Mode



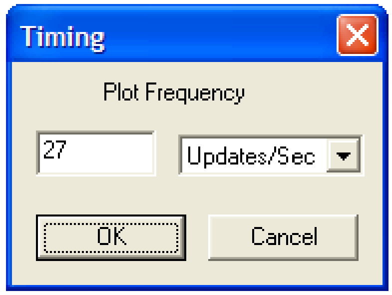
Parameter	Value	Mean	Min	Max	Std Dev
Beam Propagation Ratio (M²) Horiz	8.08	8.083	8.08	8.08	0.000
Beam Propagation Ratio (M²) Vert	10.33	10.333	10.33	10.33	0.000
Beam Parameter Product Horiz (m...	1.37	1.369	1.37	1.37	0.000
Beam Parameter Product Vert (mm ...	1.75	1.750	1.75	1.75	0.000
Beam Waist Width Horiz (µm)	249.7	249.72	249.7	249.7	0.00
Beam Waist Width Vert (µm)	257.6	257.59	257.6	257.6	0.00
Beam Waist Location Horiz (mm)	-398.29	-398.2...	-398.29	-398.29	0.000
Beam Waist Location Vert (mm)	-398.10	-398.0...	-398.10	-398.10	0.000
Divergence Horiz (mrad)	21.924	21.9243	21.924	21.924	0.0000
Divergence Vert (mrad)	27.172	27.1720	27.172	27.172	0.0000
Rayleigh Length Horiz (mm)	11.39	11.390	11.39	11.39	0.000
Rayleigh Length Vert (mm)	9.48	9.480	9.48	9.48	0.000
Beam Waist Asymmetry	0.97	0.969	0.97	0.97	0.000
Divergence Asymmetry	0.81	0.807	0.81	0.81	0.000

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



Data Collection Turns data collection on and off.

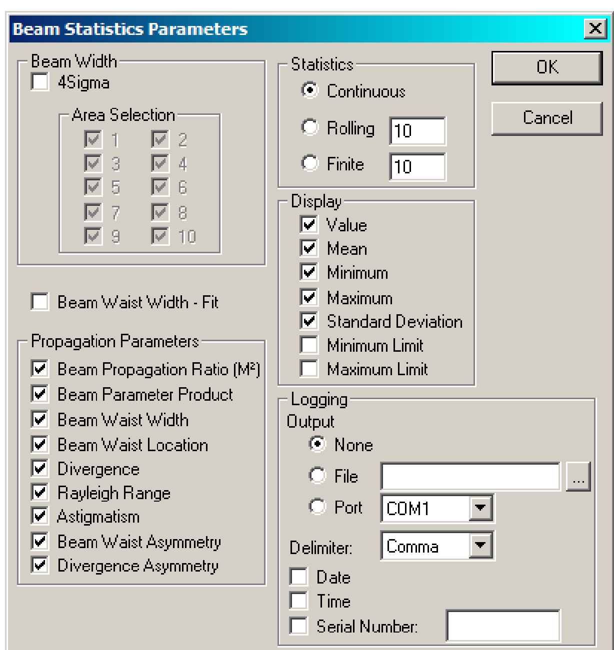
Timing… Opens a dialog box for selection of the display update rate.



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. All the parameters are computed in accordance with ISO Standards. 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. 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 for the **Beam Propagation** mode are listed below.



Beam Width (when D slit is selected in the Data Analysis Dialog Box for ISO Profiles)

13.5% Beam diameter at 13.5% clip level, either horizontal and vertical or major and minor axes. The widths for a particular beam area will be displayed if selected under **Area Selection**.

Beam Width (when D 4Sigma is selected in the Data Analysis Dialog Box for ISO Profiles)

4Sigma Second-moment beam diameter, either horizontal and vertical or major and minor axes. The widths for a particular beam area will be displayed if selected under **Area Selection**.

Area Selection

1	*Displays the width for Beam Area 1.*
2	*Displays the width for Beam Area 2.*
3	*Displays the width for Beam Area 3.*
4	*Displays the width for Beam Area 4.*
5	*Displays the width for Beam Area 5.*
6	*Displays the width for Beam Area 6.*
7	*Displays the width for Beam Area 7.*
8	*Displays the width for Beam Area 8.*
9	*Displays the width for Beam Area 9.*
10	*Displays the width for Beam Area 10.*

Beam Waist Width - Fit Displays the values of the beam waist width determined by the hyperbolic curve fit.

Propagation Parameters

Beam Propagation Ratio (M^2) The M^2 value for the laser under test, determined from the ISO 11146 standard hyperbolic fit to the test lens beam caustic.

Beam Parameter Product The Beam Parameter Product value for the laser under test, determined from the ISO 11146 standard hyperbolic fit to the test lens beam caustic.

Beam Waist Size	The beam waist size for the laser under test, determined from the ISO 11146 standard hyperbolic fit to the test lens beam caustic.
Beam Waist Location	The location of the beam waist for the laser under test, determined from the ISO 11146 standard hyperbolic fit to the test lens beam caustic.
Divergence	The divergence angle for the laser under test, determined from the ISO 11146 standard hyperbolic fit to the test lens beam caustic.
Rayleigh Range	The Rayleigh Range of the laser under test, determined from the ISO 11146 standard hyperbolic fit to the test lens beam caustic.
Astigmatism	The distance between the beam waist locations of the laser under test, expressed as a percentage of the mean laser Rayleigh Range.
Beam Waist Asymmetry	The ratio of the Beam Waist diameters, with the larger diameter as denominator, so the ratio is always ≤ 1, similar to Ellipticity.
Divergence Asymmetry	The ratio of the Beam Divergences, with the larger divergence as denominator, (ratio ≤ 1).

Statistics

Continuous	Selects a continuous average of data samples.
Rolling	Selects a rolling average with user-specified number of samples.
Finite	Selects a finite average with user-specified number of samples.

Display

Value	Selects display of the present value of the beam parameter.
Mean	Selects display of the mean value of the beam parameter.
Min	Selects display of the minimum value of the beam parameter.

Max — Selects display of the maximum value of the beam parameter.

Std Dev — Selects display of the standard deviation of the beam parameter.

Min Limit — Selects display of the minimum limit value of the beam parameter set in Limit Analysis.

Max Limit — Selects display of the maximum limit value of the beam parameter set in Limit Analysis.

Logging

Output

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 (COM).

Delimiter — 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.

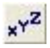
Log — If data logging is enabled, one additional set of data is acquired and then displayed and/or logged to the file. If data collection is disabled for the **Beam Statistics** window, it allows the user to take individual data one set at a time and log into a file. The Hot Key ‘Ctrl+L’ enables logging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

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

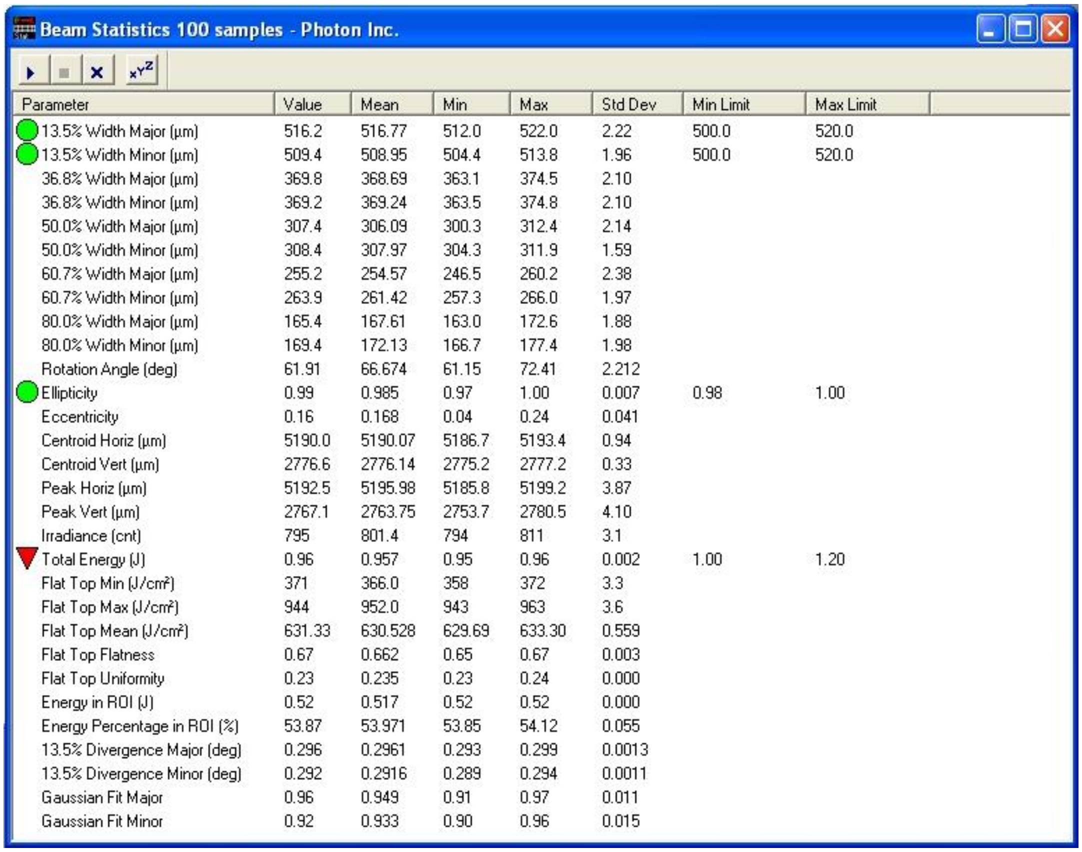
 Starts data collection

 Stops data collection

 Resets the Beam Statistics table

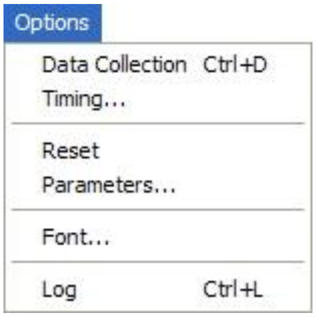
 Opens Beam **Statistics Parameters** dialog

5.2.5.2. Beam Statistics for Standard Beam Profiling Mode



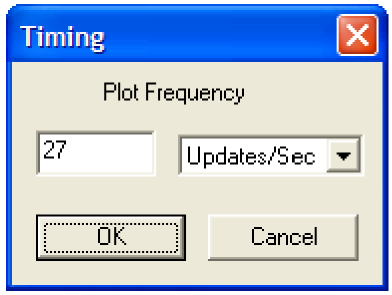
Parameter	Value	Mean	Min	Max	Std Dev	Min Limit	Max Limit
13.5% Width Major (µm)	516.2	516.77	512.0	522.0	2.22	500.0	520.0
13.5% Width Minor (µm)	509.4	508.95	504.4	513.8	1.96	500.0	520.0
36.8% Width Major (µm)	369.8	368.69	363.1	374.5	2.10		
36.8% Width Minor (µm)	369.2	369.24	363.5	374.8	2.10		
50.0% 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		

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



Data Collection Turns data collection on and off.

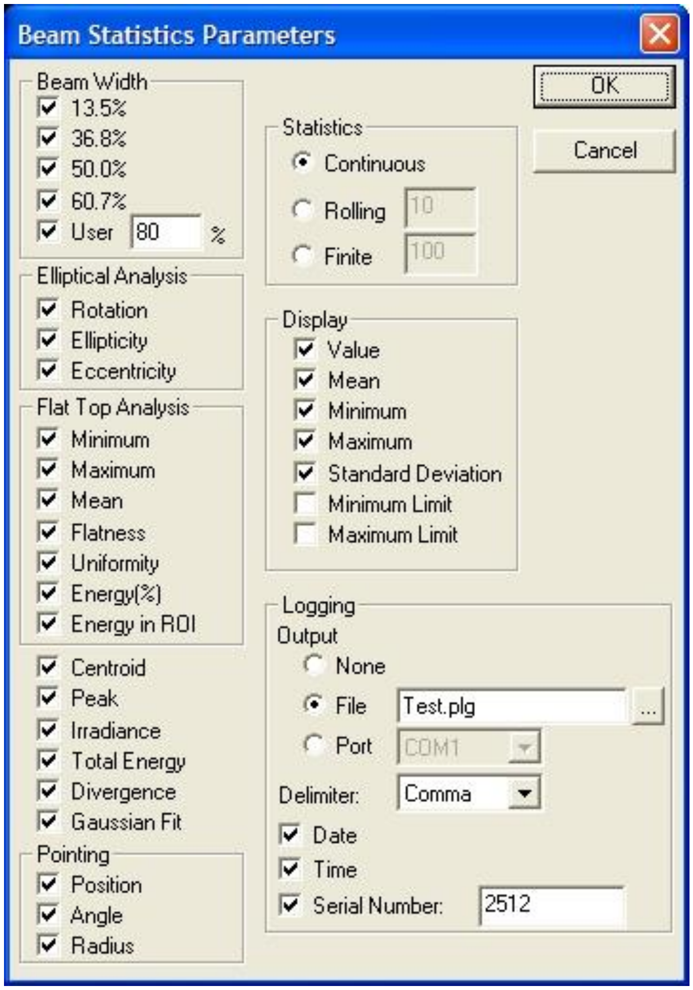
Timing… Opens a dialog box for selection of the display update rate.



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 (when D slit is selected in the Data Analysis Dialog Box for ISO Profiles)

13.5% Beam diameter at 13.5% cliplevel, horizontal and vertical or major and minor axes.

36.8% Beam diameter at 36.8% cliplevel, horizontal and vertical or major and minor axes.

50.0% Beam diameter at 50% cliplevel, horizontal and vertical or major and minor axes.

60.7% Beam diameter at 60.7% cliplevel, horizontal and vertical or major and minor axes.

User % Beam Diameter at the User Specified clip level value, horizontal and vertical or major and minor axes.

Beam Energy (when D energy is selected in the Data Analysis Dialog Box for ISO Profiles)

86.5% Beam diameter containing 86.5% of total energy, horizontal and vertical or major and minor axes.

63.2% Beam diameter containing 63.2% of total energy, horizontal and vertical or major and minor axes.

50.0% Beam diameter containing 50% of total energy, horizontal and vertical or major and minor axes.

39.3% Beam diameter containing 39.3% of total energy, horizontal and vertical or major and minor axes.

User % Beam diameter containing the user specified total energy, horizontal and vertical or major and minor axes.

Beam Width (when D 4Sigma is selected in the Data Analysis Dialog Box for ISO Profiles)

4Sigma Second-moment beam diameter, horizontal and vertical or major and minor axes.

Elliptical Analysis

Rotation Angle of the major axis with respect to horizontal.

Ellipticity Ellipticity Factor.

Eccentricity Eccentricity Factor.

Flat Top Analysis

Min Minimum value in the Energy ROI.

Max Maximum value in the Energy ROI.

Mean Mean value in the Energy ROI.

Flatness Flatness Factor.

Uniformity	Uniformity Factor.
Energy %	The percentage of Beam Area total energy or power in the Energy ROI.
Energy in ROI	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	
Position	The beam area Centroid from the **Pointing** window.
Angle	The pointing angle from the **Pointing** window.
Radius	Distance from the reference position in the **Pointing** window.
Statistics	
Continuous	Selects a continuous average of data samples.
Rolling	Selects a rolling average with user-specified number of samples.
Finite	Selects a finite average with user-specified number of samples.
Display	
Value	Selects display of the present value of the beam parameter.
Mean	Selects display of the mean value of the beam parameter.
Min	Selects display of the minimum value of the beam parameter.
Max	Selects display of the maximum value of the beam parameter.

Std Dev Selects display of the standard deviation of the beam parameter.

Min Limit Selects display of the minimum limit value of the beam parameter set in Limit Analysis.

Max Limit Selects display of the maximum limit value of the beam parameter set in Limit Analysis.

Logging

Output

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 (COM).

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

 Starts data collection

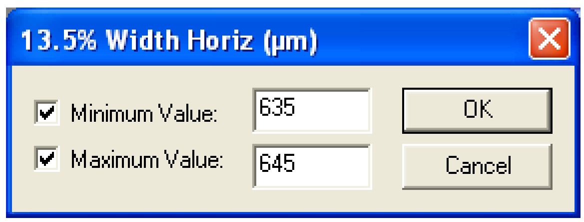
 Stops data collection

 Resets the Beam Statistics table

 Opens Beam **Statistics Parameters** dialog

5.2.5.3. 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.



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

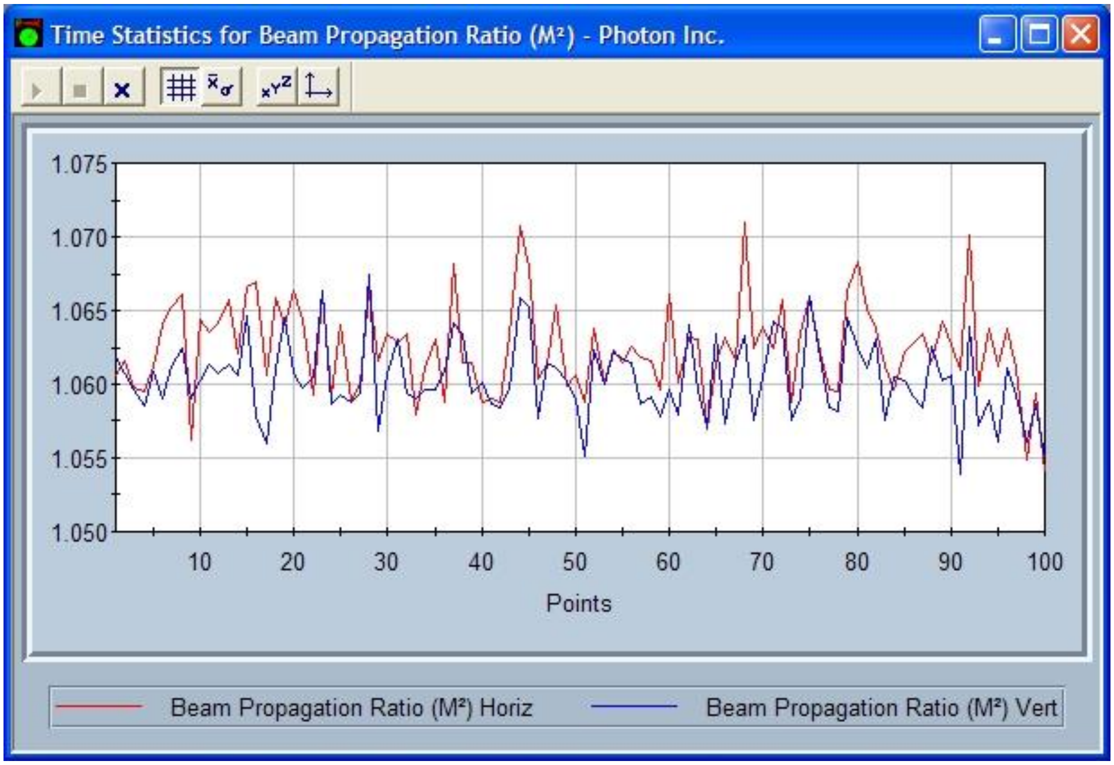
 Parameter value is within the set limit or limits.

 Parameter value is greater than the maximum limit.

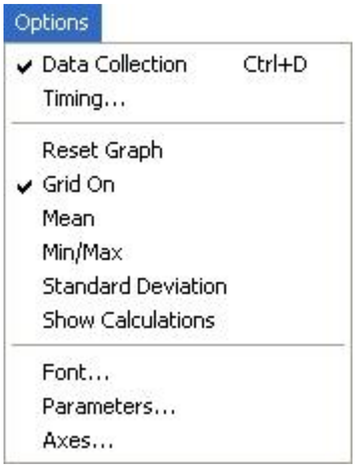
 Parameter value is less than the minimum limit.

5.2.6. 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.

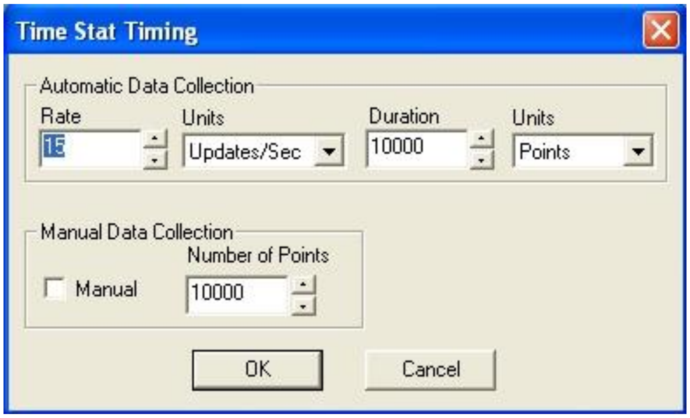


The **Options** menu available when the **Time Statistics** windows are active offer the following selections:



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.

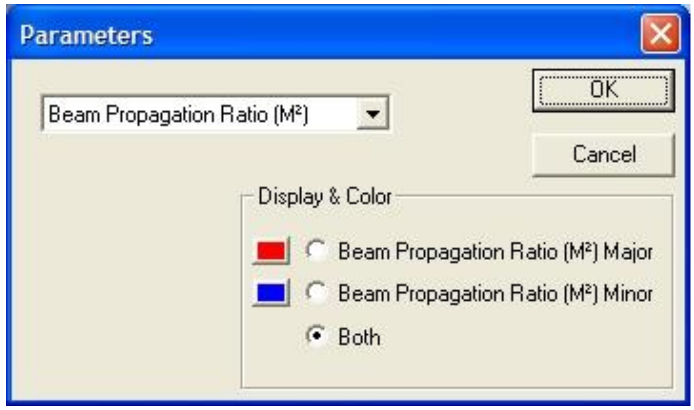
Standard Deviation When selected, an overlay plot of the standard deviation is displayed.

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 used in the chart.

Parameters…

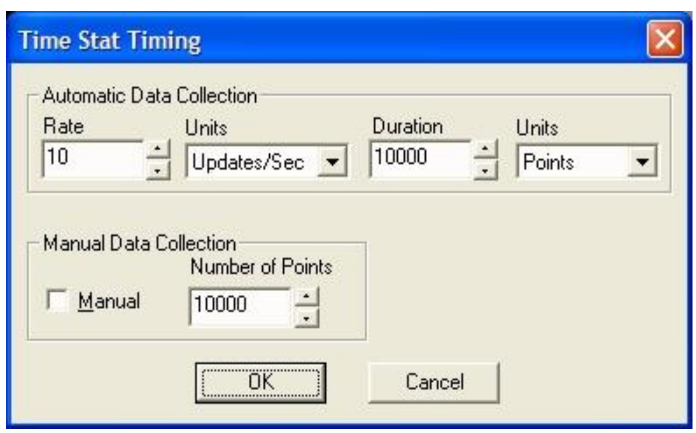
Opens the **Parameters** dialog box for selecting parameters to be plotted in the active **Time Statistics** window.



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.

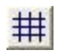


Some of the options can be selected using the **Time Statistics** window toolbar:

 **Starts** data collection

 **Stops** data collection

 **Resets** the Time Statistics graph

 **Grid overlay** on/off

 **Statistical calculations overlay** on/off

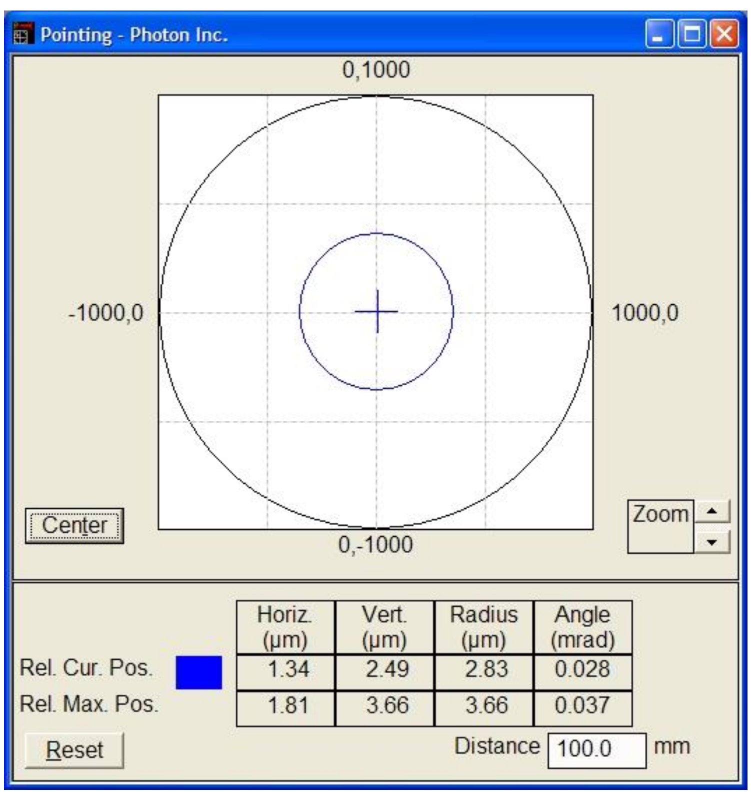
 Opens **Time Statistics Parameters** dialog

 Opens the **Time Stat Axes** dialog

5.2.7. Pointing

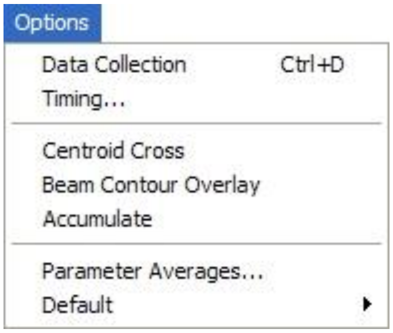
The **Pointing** window displays and tracks the location of the beam centroid in the beam area. The centroid is shown as a colored dot or cross, and also with an optional beam contour overlay.

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.

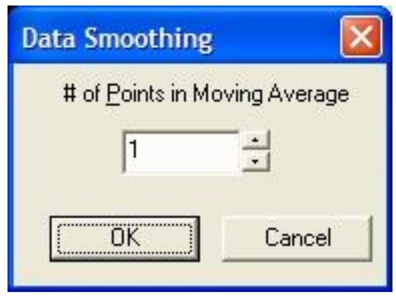
Timing… Opens a dialog box for selection of the display update rate and for how long the window will update.

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

Beam Contour Overlay When selected, a beam contour overlay is drawn around the current centroid value. The overlay is a circle or ellipse with the $1/e^2$ width of the beam.

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 centroid position value.



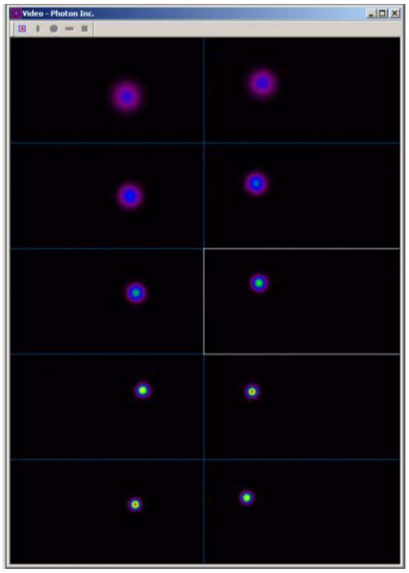
Default

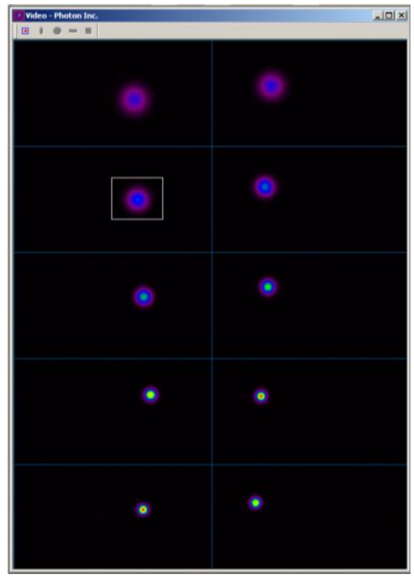
Load — Opens a dialog for loading a previously saved pointing screen setup.

Save — Opens a dialog for saving a pointing screen setup.

The **Pointing** window is available in both the Standard mode and in the Beam Propagation mode. In Standard mode The **Pointing** window displays the centroid of the beam in the Beam Area, which is either set automatically when Auto Track is selected, or set manually. In Beam Propagation mode, there are 10 Beam Areas for M^2 analysis.

As shown in the **Video** Window below, at first the **Pointing** Window defaults to the entire Beam Area #6, indicated with a white border. The Beam area can then be manually set to monitor any 1 of the 10 beams in the **Video** window. Shown below is a beam area drawn around the beam in region #3. Manual Beam Area selections are saved with the file either as *.fwd or *.fwc.





5.2.8. Notes

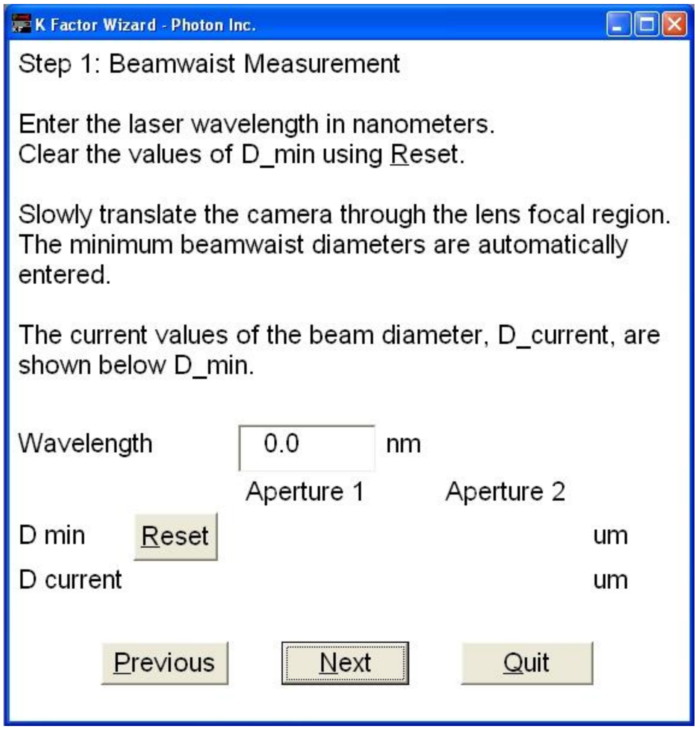
The **Notes** window is used for entering user information. When active, a cursor appears in the **Notes** window. Use the keyboard to enter text, and the arrow keys to navigate. There are no options available for the **Notes** window.

5.2.9. 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 available only in the Standard mode.

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 M^2. The calculated values are displayed in the final dialog box.



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!

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)

5.2.9.1. 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 $M = 1.2$ 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# ≥20) should be used. You also need the wavelength and the minimum observed beam width, D_{min}, while sweeping through the beam waist.

5.2.9.2. 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 0.7µm and approximate exit beam width is 500µm ($1/e^2$).

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

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

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 125µm, the required focal length is:

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

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

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

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 135µm calculated spot width.

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

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

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 $K = 1$ in order 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.

5.2.9.3. 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 (5.2.9.2) this means one should see no more than ±500µm motion either *X* or *Y* as one translates the sensor along the beam axis through a distance of 2*Z* (or 41mm for our example).

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

5.2.9.4. 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 2*Z* length and again try to keep the cross translation to less than ±1-2 beam widths. For the example beam, use the calculated 135µm 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.

5.2.9.5. Rayleigh Test Fixture Accessory

Spiricon 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 25µm. The total 150mm travel allows the Rayleigh range to be such that a beam waist of approximately 200µm 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.

5.2.9.6. 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 5.1 shows what this looks like.

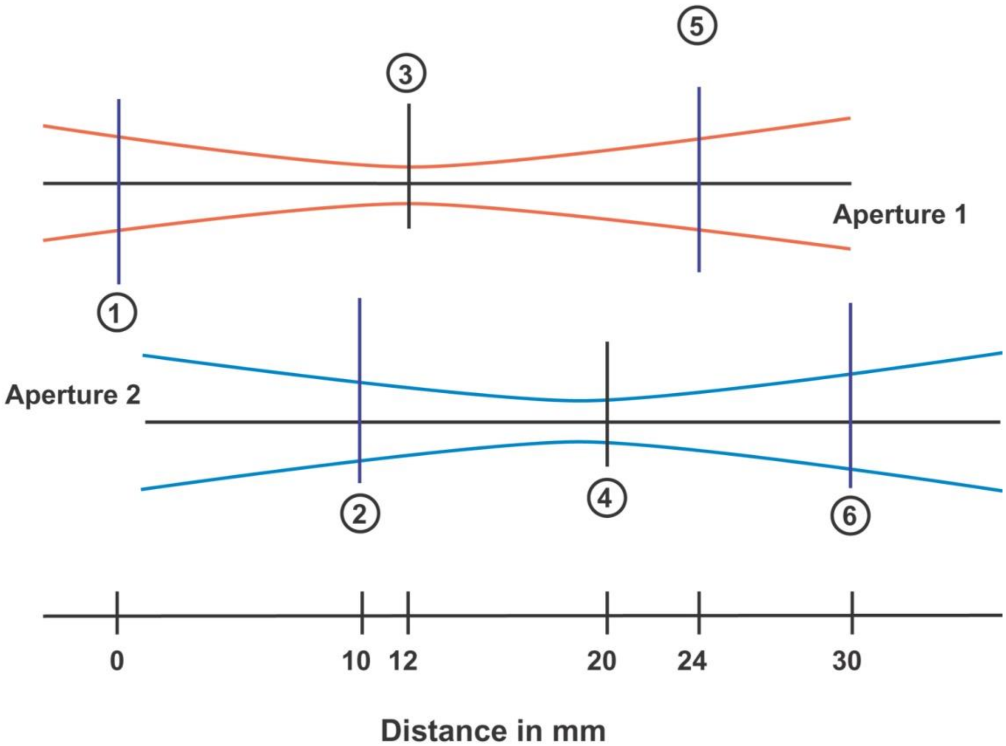


Figure 5.1 Measurement on Astigmatic Source Using the K-Factor Wizard

Example Using the Rayleigh Test Fixture Accessory:

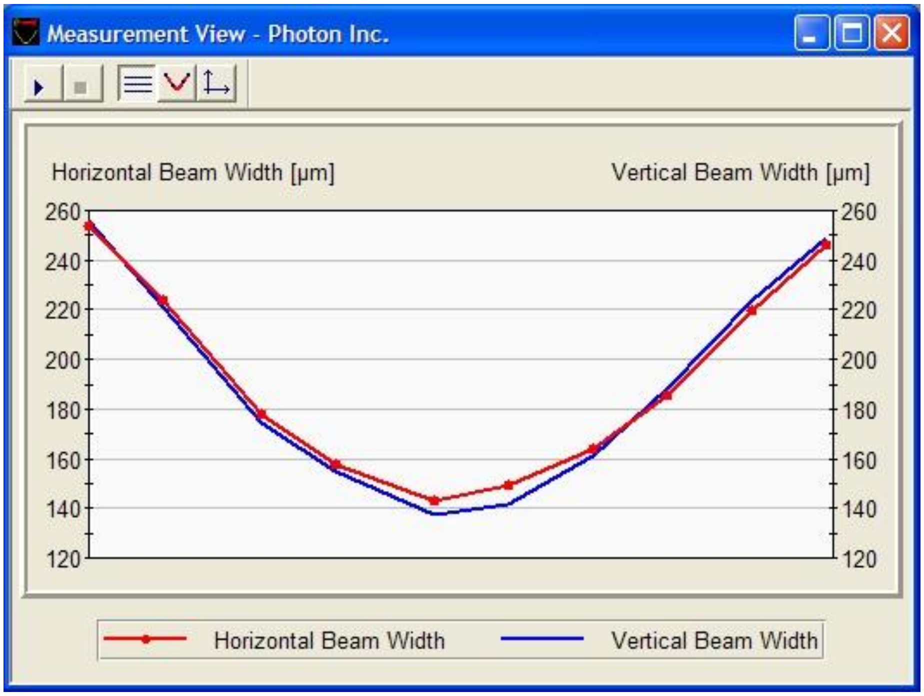
1. Move the sensor to *D* Target for Aperture 1. Reset the Mitutoyo scale. Enter 0 for *Z* Position 1 under the Aperture 1 heading.
2. Move the sensor to *D* Target for Aperture 2. Enter 10 for *Z* Position 1 under the Aperture 2 heading. Select the Next button.
3. Move slowly through the waist for Aperture 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.

5.2.10 Measurement

The **Measurement** window displays the beam propagation caustics measured with the ModeScan Model 1780.

This window is available only in the Beam Propagation mode.

The display shows the Horizontal and Vertical caustics or the Major and Minor caustics if the system is set for Elliptical Analysis. The caustic is obtained from simultaneous measurement of 10 spots at 10 locations in the propagation path.

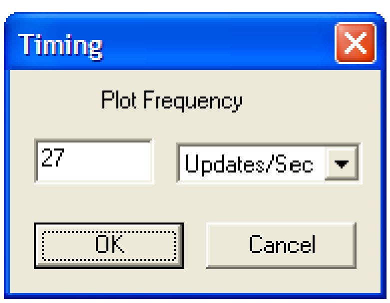


The **Options** menu available when the **Measurement** window is active is shown below.

The selections are:

Data Collection Turns data collection on and off.

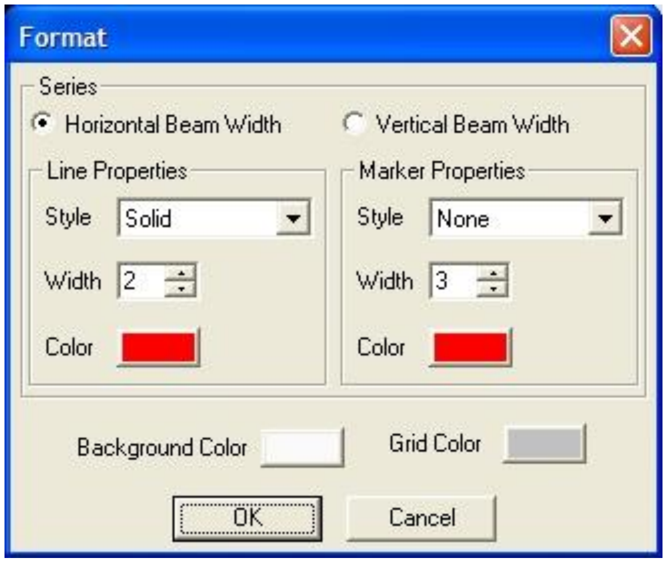
Timing… Opens a dialog box for selection of the display update rate.



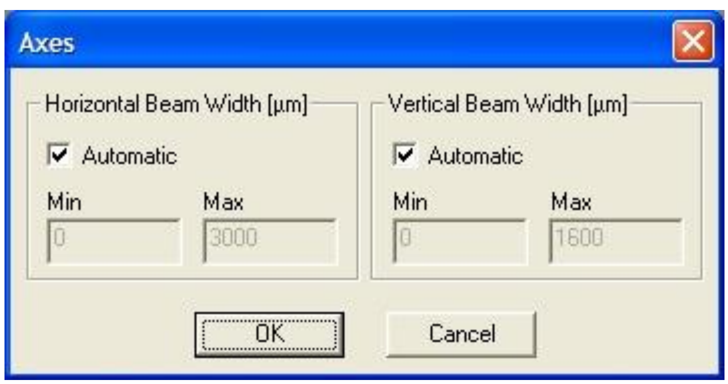
Grid On When selected, a grid overlay is displayed on the

Measurement graph.

Format… Opens a dialog box for formatting the beam caustic graphs in the **Measurement** view. Each caustic graph is customized independently. Customization features are the Line style, width, and color, and the Marker style width and color. Additionally, the Background and Grid colors can be selected.



Axes… Opens a dialog box for selection of manual or automatic configuration of the axes in the **Measurement** window.



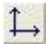
Some of these options can also be selected using the **Measurement** window toolbar:

 Starts data collection.

 Stops data collection.

 Grid overlay on/off.

 Opens the Format dialog box.

 Opens Axes dialog box.

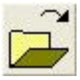
5.3. Toolbars

Toolbars are provided to speed access to some of the most commonly used operations and features of the FireWire BeamPro 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, **Time Statistics** window and **Measurement** 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.

5.3.1. The Main Toolbar

 Opens a new file

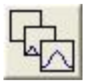
 Opens the **Open** file dialog

 Saves the current file

 Opens the **Print** dialog

 Opens specific **Help** topics (currently inactive)

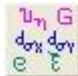
 Turns **Autotracking** on/off

 Turns **Track Settings** on/off (currently inactive)

 Turns **Global Data Collection** on/off

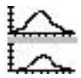
 Opens the **Calibration** dialog (also indicates the calibration status)

Sets system to **Laser Positioning** mode



Sets system to **Analysis** mode

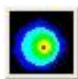
Sets system to **Single Shot** mode



Opens the **Profile** window

Opens the **Video** window

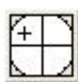
Opens the **3D Profile** window. Up to 5 2D and 3D windows combined can be opened.



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 a **Measurement** window

Opens the **Notes** window.

5.3.2. The Video Window Toolbar

Set **Beam Area**

Energy ROI: **Elliptical**

Energy ROI: **Circular**

Energy ROI: **Rectangular**

Energy ROI: **Square**

5.3.3. The Profile Window Toolbar

 Starts data collection

 Stops data collection

 **Gaussian Fit** overlay on/off

 Turns **Normalization** on/off

5.3.4. The Beam Statistics Window Toolbar

 **Starts** data collection

 **Stops** data collection

 **Resets** the Beam Statistics table

 Opens **Beam Statistics Parameters** dialog

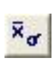
5.3.5. The Time Statistics Window Toolbar

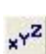
 **Starts** data collection

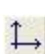
 **Stops** data collection

 **Resets** the active Time Statistics graph

 **Grid overlay** on/off

 **Statistical calculations overlay** on/off

 Opens **Time Statistics Parameters** dialog

 Opens **Time Stat Axes** dialog

5.3.6. The Measurement Window Toolbar

 **Starts** data collection

 **Stops** data collection

 **Grid overlay** on/off

 Opens **Format** dialog

 Opens **Axes** dialog

5.4. Status Bar

The status bar at the bottom of the screen displays the camera settings (gain and exposure), cursor location and the Beam Area information. The first pane displays the camera settings: gain (in dB) and exposure (in ms)**.** The second pane displays the 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.

5.5. ActiveX Automation

FireWire BeamPro Acquisition and Analysis Software provides a Microsoft Automation interface. As an automation server, FireWire BeamPro 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 FireWire BeamPro Acquisition and Analysis Software.

The type library *"FWBeamPro.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 FireWire BeamPro Analysis Software exports are explained below.

5.5.1 ShowWindow

Property Type:

VT_BOOL – Show flag

Remarks:

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

5.5.2. AcquisitionMode

Property Type:

VT_I2 – acquisition mode

Remarks:

Gets or sets acquisition mode.

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

Acquisition Mode Selection	Value	Comments
SEL_ACQMODE_ANALYSIS	0	Analysis Acquisition Mode
SEL_ACQMODE_LASERPOS	1	Laser Positioning Acquisition Mode
SEL_ACQMODE_SINGLESHOT	2	Single Shot Acquisition Mode

5.5.3. 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

5.5.4. 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.

5.5.5. 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

5.5.6. 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.

5.5.7. 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.

5.5.8. 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 between 0.02 to 81.90 for the Models 2518 and 2523 and between 0.02 and 27.52 for the Model 2512. The exposure increment is 0.02ms.

5.5.9. CameraGain

Property Type

VT_I2 – camera gain

Remarks:

Gets or sets the gain for the camera, in dB. The range for the gain value is between 0 and 12 for Models 2512 and 2523 and between 0 and 7 for Model 2518. The gain increment is 1dB.

5.5.10. CameraAutoSettings

Method Return Value:

VT_BOOL –Automatic Settings status

Method Parameter List:

VTS_NONE – none

Remarks:

Performs a one-shot automatic setting of exposure and gain. If the operation was successful, the method returns TRUE, otherwise returns FALSE.

5.5.11. 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 milliradians
SEL_ANGLE_UNITS_DEG	1	Reports all the angles in degrees

5.5.12. GlobalDataCollection

Property Type:

VT_BOOL – global data collection

Remarks:

Starts or stops global data collection and queries the state of it

5.5.13. AutoTracking

Property Type:

VT_BOOL – auto track

Remarks:

Enables or disables the auto track feature and queries the state of it.

5.5.14. SetBeamArea

Method Return Value:

VT_BOOL – TRUE if Beam Area has been modified successfully, FALSE otherwise.

Method Parameter List:

VTS_R4 – left

VTS_R4 – right

VTS_R4 – top

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.

5.5.15. GetBeamArea

Method Return Value:

VT_BOOL – Beam Area status

Method Parameter List:

VTS_PR4 – left

VTS_PR4 – top

VTS_PR4 – right

VTS_PR4 – bottom

Remarks:

Gets the Beam Area coordinates. 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 there is no Beam Area the return value is FALSE. If there is a valid Beam Area the return value is TRUE.

5.5.16. DoCalibration

Method Return Value:

VT_BOOL – TRUE if calibration was successfully, FALSE otherwise.

Method Parameter List:

VTS_NONE – none

Remarks:

Performs a calibration routine for the camera.

5.5.17. 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.

5.5.18. 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	0	No background subtraction
SEL_BKGND_FRAME	1	Frame subtraction
SEL_BKGND_MEAN	2	Mean subtraction

5.5.19. ComputationsDone

Property Type:

VT_BOOL – computations status

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.

5.5.20. 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.

5.5.21. IsSaturated

Method Return Value:

VT_BOOL – saturation flag

Method Parameter List:

VTS_NONE – none

Remarks:

Returns TRUE if signal is saturated, FALSE otherwise.

5.5.22. 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.

5.5.23. UseCliplevel

Method Return Value:

VT_EMPTY – none

Method Parameter List:

VTS_R4 – cliplevel in percentage

VTS_BOOL – use

Remarks:

Enables or disables 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 FireWire BeamPro may not be valid.

This function has to be called only once, at the beginning of the program, before any call to GetWidth, GetEllipticity, GetEccentricity or GetPeakDivergence.

5.5.24. GetWidth

Method Return Value:

VT_R4 – beam width

Method Parameter List:

VTS_I2 – axis

VTS_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 GetWidth.

5.5.25. GetPeakPosition

Method Return Value:

VT_R4 – peak position

Method Parameter List:

VTS_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.

5.5.26. GetCenter

Method Return Value:

VT_R4 – centroid position

Method Parameter List:

VTS_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.

5.5.27. GetPeakIrradiance

Method Return Value:

VT_I2 – peak irradiance

Method Parameter List:

VTS_NONE – none

Remarks:

Returns the irradiance of the peak. Possible values are 0…4095.

5.5.28. EllipticAnalysis

Property Type:

VT_BOOL – elliptic analysis

Remarks:

Gets or sets the elliptical analysis state.

If the state is TRUE, the elliptical analysis is enabled and GetRotationAngle, GetEllipticity and GetEccentricity will return valid numbers. If the state is FALSE, the elliptical analysis is disabled.

5.5.29. GetRotationAngle

Method Return Value:

VT_R4 – rotation angle

Method Parameter List:

VTS_NONE – none

Remarks:

Returns the orientation of the computed major axis (the angle is reported in trigonometric direction).

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

5.5.30. GetEllipticity

Method Return Value:

VT_R4 – ellipticity

Method Parameter List:

VTS_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 property.

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.

5.5.31. GetEccentricity

Method Return Value:

VT_R4 – eccentricity

Method Parameter List:

VTS_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 property.

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.

5.5.32. GetTotalEnergy

Method Return Value:

VT_R4 – total energy

Method Parameter List:

VTS_NONE – none

Remarks:

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

5.5.33. 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.

5.5.34. FlatTopAnalysis

Property Type:

VT_BOOL – flat top analysis

Remarks:

Gets or sets the flat top analysis state.

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

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

5.5.35. GetFlatTopMin

Method Return Value:

VT_R4 – flat top minimum

Method Parameter List:

VTS_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.

5.5.36. GetFlatTopMax

Method Return Value:

VT_R4 – flat top maximum

Method Parameter List:

VTS_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.

5.5.37. 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.

5.5.38. 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.

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

5.5.39. 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.

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

5.5.40. GetFlatTopEnergy

Method Return Value:

VT_R4 – flat top energy

Method Parameter List:

VTS_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 and if energy analysis has been enabled using.

5.5.41. GaussianFitAnalysis

Property Type:

VT_BOOL – Gaussian Fit analysis

Remarks:

Gets or sets the Gaussian analysis state.

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

5.5.42. Get1dGaussianFit

Method Return Value:

VT_R4 – Gaussian fit

Method Parameter List:

VTS_I2 – axis

Remarks:

Returns Gaussian fit numbers.

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

Gaussian fit numbers are computed for the profiles, either pinhole or slit scan through the data. In FireWire BeamPro these profiles and their correspondent Gaussian fitted profiles can be visualized in the Profile view.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis property), 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.

The profile type (slit or pinhole scan) can be modified with the ProfileType method; for the pinhole scans the Cross Hair type can be modified using the ProfileCrossHairsType method, while the position can be modified using and SetProfileCrossHairsPos, respectively GetProfileCrossHairsPos properties.

5.5.43. 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_PTSRC	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.

5.5.44. GetDivergenceMethod

Method Return Value:

VT_EMPTY – none

Method Parameter List:

VTS_PI2 – divergence method

VTS_PR4 – distance

VTS_PR4 – cliplevel

Remarks:

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

5.5.45. GetDivergence

Method Return Value:

VT_R4 – divergence

Method Parameter List:

VTS_I2 – axis

Remarks:

Returns the divergence.

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

The divergence is returned in the unit selected by AngleUnits if the selected divergence method is Lens or PointSource and is unitless if the selected divergence method is Numeric Aperture.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis property), 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.

5.5.46. 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.

5.5.47. 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

5.5.48. SetProfileCrossHairsPos

Method Return Value:

VT_BOOL –flag indicating 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 (the point of coordinates (0, 0) is the upper left corner of the array). This method can be called only if the Profile Type is set to Slit (Equivalent Slit Profiles).

5.5.49. GetProfileCrossHairsPos

Method Return Value:

VT_BOOL – flag indicating 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. The point of coordinates (0, 0) is the upper left corner of the array.

5.5.50. GetProfileData

Method Return Value:

VT_VARIANT – profile data array

Method Parameter List:

VTS_I2 – axis

VTS_I4 – start index

VTS_I4 – number of points

Remarks:

Returns an array of data points that represent a pinhole or slit scan through the beam area. (In FireWire BeamPro interface these profiles can be visualized in the Profile view.)

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis property), 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.

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.

The profile type (slit or pinhole scan) can be modified with the ProfileType method; for the pinhole scans the Cross Hair type can be modified using the ProfileCrossHairsType method, while the position can be modified using and SetProfileCrossHairsPos, respectively GetProfileCrossHairsPos properties.

5.5.51. GetProfileSampleSize

Method Return Value:

VT_R4 – sample size

Method Parameter List:

VTS_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 property), 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.

5.5.52. GetProfileNumPts

Method Return Value:

VT_I2 – number of points

Method Parameter List:

VTS_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 property), 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.

5.5.53. GetSampleSize

Method Return Value:

VT_R4 – sample size

Method Parameter List:

VTS_NONE – none

Remarks:

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

5.5.54. GetNumPts

Method Return Value:

VT_I4 – number of points

Method Parameter List:

VTS_I2 – axis

Remarks:

Returns the number of points inside the beam area along the designated axis.

Possible values for the axis are 0 and 1. If analysis has been enabled (see EllipticAnalysis property), 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.

5.5.55 GetTotalSize

Method Return Value:

VT_I4 – total size

Method Parameter List:

VTS_I2 – axis

Remarks:

Returns the total span of the profiles, either slit or pinhole, in microns.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis property), 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.

5.5.56. GetStartPos

Method Return Value:

VT_I4 – start position

Method Parameter List:

VTS_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 (horizontal) and 1 (vertical), where horizontal and vertical are relative to the camera.

5.5.57. 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 4095). 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).

5.5.58. 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.

5.5.59. 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 (camera identifiers). The first element in the array always corresponds to the camera that is currently used by the FireWire BeamPro software. These strings need to be passed as parameter to SelectCamera method in order to select a specific camera.

5.5.60. SelectCamera

Method Return Value:

VT_BOOL – Camera Select status

Method Parameter List:

VTS_BSTR – Camera identfier

Remarks:

Selects a different camera for use with the FireWire BeamPro 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. If a different model camera was selected it is possible that Beam area, Region of interest and the user defined cross hairs position may be automatically modified by the software; therefore it is highly recommended either to set the desired values or to retrieve the values from the software and check them against the desired values. Also it is recommended to retrieve other important parameters from software, i.e. the sample size.

5.5.61. IsBeamPropagation

Method Return Value:

VT_BOOL – Beam Propagation Availability.

Method Parameter List:

VTS_NONE – none

Remarks:

Returns TRUE if the selected camera is part of ModeScan Model 1780 and therefore allows the software to enable Beam Propagation Analysis mode.

5.5.62. BeamPropagationAnalysis

Property Type:

VT_BOOL – Beam Propagation analysis

Remarks:

Gets or sets the Beam Propagation analysis state.

If this state is TRUE, the Beam Propagation analysis is enabled and Beam Propagation parameters be computed. Also, all the Beam Propagation characteristics can be set or get if this analysis is on. If the state is FALSE the Beam Propagation analysis is disabled.

To set this property to TRUE the system should be part of the ModeScan Model 1780 (it can be verified with IsBeamPropagation method).

5.5.63. SetBeamPropagationParameters

Method Return Value:

VT_BOOL – TRUE if Beam Propagation parameters were set successfully, FALSE otherwise.

Method Parameter List:

VTS_R4 – laser wavelength

VTS_R4 – laser reference position

VTS_R4 – lens focal length

VTS_R4 – lens nominal position

Remarks:

Returns TRUE if all the following are all true: the selected camera is part of the ModeScan Model 1780 system, the Beam Propagation Analysis mode is enabled and all the parameters were set successfully. In all the other cases the method returns FALSE. The laser wavelength is specified in nm, while all the other parameters are specified in mm. The lens nominal position, the laser reference position and the focal length must be positive numbers.

5.5.64. GetBeamPropagationParameters

Method Return Value:

VT_BOOL – TRUE if Beam Propagation parameters were retrieved successfully, FALSE otherwise.

Method Parameter List:

VTS_PR4 – laser wavelength

VTS_PR4 – laser reference position

VTS_PR4 – lens focal length

VTS_PR4 – lens nominal position

Remarks:

Retrieves the parameters associated with Beam Propagation Analysis mode. The parameter list values are the laser wavelength (in nm), the laser position (in mm), the lens focal length (in mm) and the lens position (in mm). If the Beam Propagation Analysis (see the BeamPropagationAnalysis property) is not enabled this method returns FALSE.

5.5.65. GetBeamPropagationRatio

Method Return Value:

VT_R4 – Beam propagation ratio (M^2)

Method Parameter List:

VTS_I2 – axis

Remarks:

Returns the beam propagation ratio.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see the EllipticAnalysis property), 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.

The Beam Propagation Analysis must be enabled (see the BeamPropagationAnalysis property) and all the parameters set appropriate in order to obtain accurate results.

5.5.66. GetBeamWaistSize

Method Return Value:

VT_R4 – Beam waist size (in µm)

Method Parameter List:

VTS_I2 – axis

Remarks:

Returns the beam propagation ratio.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see the EllipticAnalysis property), 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.

The Beam Propagation Analysis must be enabled (see the BeamPropagationAnalysis property) and all the parameters set appropriate in order to obtain accurate results.

5.5.67. GetBeamWaistLocation

Method Return Value:

VT_R4 – Beam waist location (in mm)

Method Parameter List:

VTS_I2 – axis

Remarks:

Returns the beam waist location.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see the EllipticAnalysis property), 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.

The Beam Propagation Analysis must be enabled (see the BeamPropagationAnalysis property) and all the parameters set appropriate in order to obtain accurate results.

5.5.68. GetRayleighRange

Method Return Value:

VT_R4 – Rayleigh range (in mm)

Method Parameter List:

VTS_I2 – axis

Remarks:

Returns the Rayleigh range.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see the 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.

The Beam Propagation Analysis must be enabled (see the BeamPropagationAnalysis property) and all the parameters set appropriate in order to obtain accurate results.

5.5.69. GetAstigmatism

Method Return Value:

VT_R4 – Astigmatism value (in %)

Method Parameter List:

VTS_NONE – none

Remarks:

Returns the beam astigmatism value.

The Beam Propagation Analysis must be enabled (see the BeamPropagationAnalysis property) and all the parameters set appropriate in order to obtain accurate results.

5.5.70 GetWaistAsymmetry

Method Return Value:

VT_R4 – Beam Waist Asymmetry value

Method Parameter List:

VTS_NONE – none

Remarks:

Returns the beam waist asymmetry value.

The Beam Propagation Analysis must be enabled (see the BeamPropagationAnalysis property) and all the parameters set appropriate in order to obtain accurate results.

5.5.71. GetDivergenceAsymmetry

Method Return Value:

VT_R4 – Divergence Asymmetry

Method Parameter List:

VTS_NONE – none

Remarks:

Returns the divergence asymmetry value.

The Beam Propagation Analysis must be enabled (see the BeamPropagationAnalysis property) and all the parameters set appropriate in order to obtain accurate results.

5.5.72. GetBeamWaistWidthFromFit

Method Return Value:

VT_R4 – Beam Waist Width determined by the hyperbolic curve fit

Method Parameter List:

VTS_I2 – axis

Remarks:

Returns the beam waist width determined by the hyperbolic curve fit.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see the 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.

The Beam Propagation Analysis must be enabled (see the BeamPropagationAnalysis property) and all the parameters set appropriate in order to obtain accurate results.

5.5.72. GetBeamParameterProduct

Method Return Value:

VT_R4 – Beam Parameter Product

Method Parameter List:

VTS_I2 – axis

Remarks:

Returns the Beam Parameter Product computed from the values of beam waist radius and far field half angle divergence.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see the 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.

The Beam Propagation Analysis must be enabled (see the BeamPropagationAnalysis property) and all the parameters set appropriate in order to obtain accurate results.

5.5.73. Example files

In the Automation folder under the folder where the software has been installed (the default settings is "C:\Program Files\Photon\FireWire BeamPro"*) there are two detailed examples about using ActiveX: one written in Visual Basic for Application (VBA) using Microsoft Excel "FireWire BeamPro ActiveX Example.xls" and one developed in LabVIEW "FireWire BeamPro ActiveX Example.vi". For the ModeScan Model 1780 there is another example file developed in VBA using Microsoft Excel "*M^2 FireWire BeamPro ActiveX Example.xls*".*