USER MANUAL

11Beamage-3
USB 3.0 Beam Profiling Camera

WARRANTY

The Standa 11Beamage-3 beam profiler carries a one-year warranty (from date of shipment) against material and/or workmanship defects, when used under normal operating conditions. The warranty does not cover damages related to battery leakage or misuse.

Standa Ltd. will repair or replace, at Standa's option, any 11Beamage-3 that proves to be defective during the warranty period, except in the case of product misuse.

Any attempt by an unauthorized person to alter or repair the product voids the warranty.

The manufacturer is not liable for consequential damages of any kind.

Customers must fill in and mail the warranty card in order to activate the warranty.

In case of malfunction, contact your local Standa distributor or Standa office to obtain a return authorization number. The material should be returned to:

Standa Ltd.
Svitrigailos 4-39
03222 Vilnius
Lithuania

Tel: +370-5-2651474
Fax: +370-5-2651483
e-mail: sales@standa.LT

Website: www.standa.LT

CLAIMS

To obtain warranty service, contact Standa or send the product, with a description of the problem, and prepaid transportation and insurance, to Standa. Standa assumes no risk for damage during transit. Standa will, at its option, repair or replace the defective product free of charge or refund your purchase price. However, if Standa determines that the failure is caused by misuse, alterations, accident or abnormal conditions of operation or handling, you will be billed for the repair and the repaired product will be returned to you, transportation prepaid.

SAFETY INFORMATION

Do not use the 11Beamage-3 if the device or the detector looks damaged, or if you suspect that the 11Beamage-3 is not operating properly.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy. If not installed and used in accordance with the instructions, it may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, try to correct the interference by taking one or more of the following steps:

- Reorient or relocate the receiving antenna.
- Increase the distance between the equipment and receiver.
- Connect the equipment to an outlet that is on a different circuit than the receiver.
- Consult the dealer or an experienced radio/TV technician for help.

Caution: Changes or modifications not expressly approved in writing by Standa may void the user's authority to operate this equipment.

SYMBOLS

The following international symbols are used in this manual:

Refer to the manual for specific Warning or Caution information to avoid any damage to the product.

DC, Direct Current

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1. 11BEAMAGE-3

1.1. INTRODUCTION

Standa introduces the new 11Beamage-3. Its sleek and thin design allows the 11Beamage-3 to fit between tight optical components. Its USB 3.0 connection and improved algorithm allows very fast frame rates. The new 2.2 MPixel CMOS sensor has a large ⅔" optical format with a small 5.5 μm pixel pitch allowing high resolution on large beams. Most importantly the innovative and improved PC-Beamage-3.0 software is simple and intuitive to any new or expert beam profiling user.

1.2. SPECIFICATIONS

The following specifications are based on a one-year calibration cycle, an operating temperature of 18 to 28ºC (64 to 82ºF) and a relative humidity not exceeding 80%.

Table 1-1 List of Specifications

	Sensor Specification
Sensor Technology	CMOS without coverglass
Sensor Size	11.3 x 6.0 mm
Sensor Area	0.67 cm^2
Pixel Count	2.2 MPixels
Pixel H x V	2048 x 1088
Optical Format	⅔"
Pixel Dimension	5.5 μm
Minimum Measurable Beam	55 μm
ADC	12 bit (default) or 10 bit
Shutter Type	Global
Wavelength Range	350 -1150 nm
Frame Rate	9 fps (2.2 MPixel Full Frame) 12 fps (1.1 MPixel Active Area 2048 x544) 16 fps (0.016 MPixel Active Area 128 x 128)
RMS noise	1000:1 (60 dB)
Minimum and Maximum Exposure Times	0.06 to 100 ms
External Trig	SMA connector 1.1 volts to 24 volts, the rise edge response time is 300 ns Trigger signal pulse width: 300 ns to 230 ms Optional SMA to BNC adaptor (202273) :

	Damage Thresholds
Maximum Average Power	1 W with ND filter
Saturation Level (1064 nm, CW, ND4)	10 W/cm^2
Saturation Level (1064 nm, Pulsed, ND4)	300 µJ/cm^2
	PC Requirements
USB Port	USB 3.0 port for optimal performance USB 2.0 port
Operating System Compatibility	Windows 8 Windows 7 Windows Vista
Average RAM allocation	500 MB
PC Recommended Requirement	4 Gb RAM minimum Intel i series processors (i3, i5, i7) or equivalent for optimal performance, other processors will have lower specifications.
Internet Upgrades	Downloadable at website
	Physical Characteristics
Dimensions	61 H x 81.1W x 19.7D
Weight	138 g
Default Attenuation	ND 4.0
	Measured and Displayed Parameters
Displays	3D, 2D, XY (crosshair), Beam Tracking
Beam Diameter Definition	4 Sigma (ISO) - ISO-11146-1:2005 FWHM along crosshair (50%) 1/e^2 along crosshair (13.5%) 86% effective diameter (D86)
Beam Center Definition	Centroid - ISO-11146-1:2005 First Encountered Peak

Displayed Measurements	Major Axis Minor Axis Effective Diameter Ellipticity Orientation Centroid X and Y Peak X and Y Peak Saturation Level Peak to Average Ratio X and Y Divergence Fitted Gaussian equations Roughness fit along crosshairs Gaussian fit along crosshairs Mean Centroid Position Azimuth Beam Position Stabilty
Setup Options	Exposure Time (auto or manual) Image Orientation (rotation and flip) Image Averaging (temporal filter) Active Area Pixel Addressing Gain ADC Level Magnifying Lens
Processing Option	Background Subtraction Area Filters (triangular and flat spatial filters) Normalized Display Trigger
Buffer	Buffer size from 1 to 32 frames Possibility to animate stored frames
File options	Save 1 or all images in buffer Save in native format, text format, or binary format Load native format files Print report Save 3D or 2D image in bitmap format Save crosshairs in text format Data Acquisition of measurements in text format and in native format

1.2.1.11Beamage-3 Mechanical Drawings
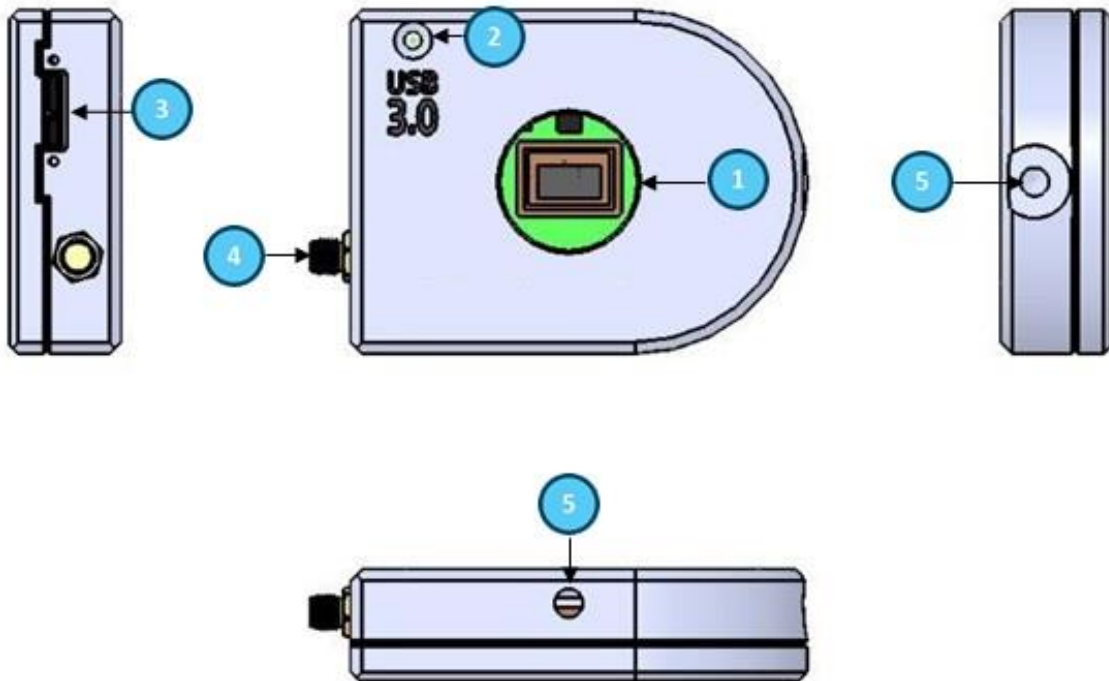
Figure 1-1 11Beamage-3 Front and Side Views

(1) **Aperture:** The 11Beamage-3's aperture and screw threads are C-MOUNT allowing easy connectivity with optical accessories such as attenuation filters, UV converters or lenses. The sensor is centered with the aperture's center.

(2) **LED Indicator:** The LED indicates if the 11Beamage-3 has been detected by the computer and if it is currently streaming.

(3) **USB 3.0 connector:** The USB 3.0 connector is now more rugged with its screwable holes. Please note that only USB 3.0 compliant cables can be used with the 11Beamage-3. USB 2.0 ports can be used, but it will lower the 11Beamage-3 speed performances.

(4) **SMA connector:** The SMA connector is used to externally trigger the 11Beamage-3. A SMA to BNC adaptor is available.

(5) **Post holes:** ¼"-20 holes are aligned with the sensor's center allowing easy optical alignment.

1.2.2. Sensor and Filter Spectral Responses
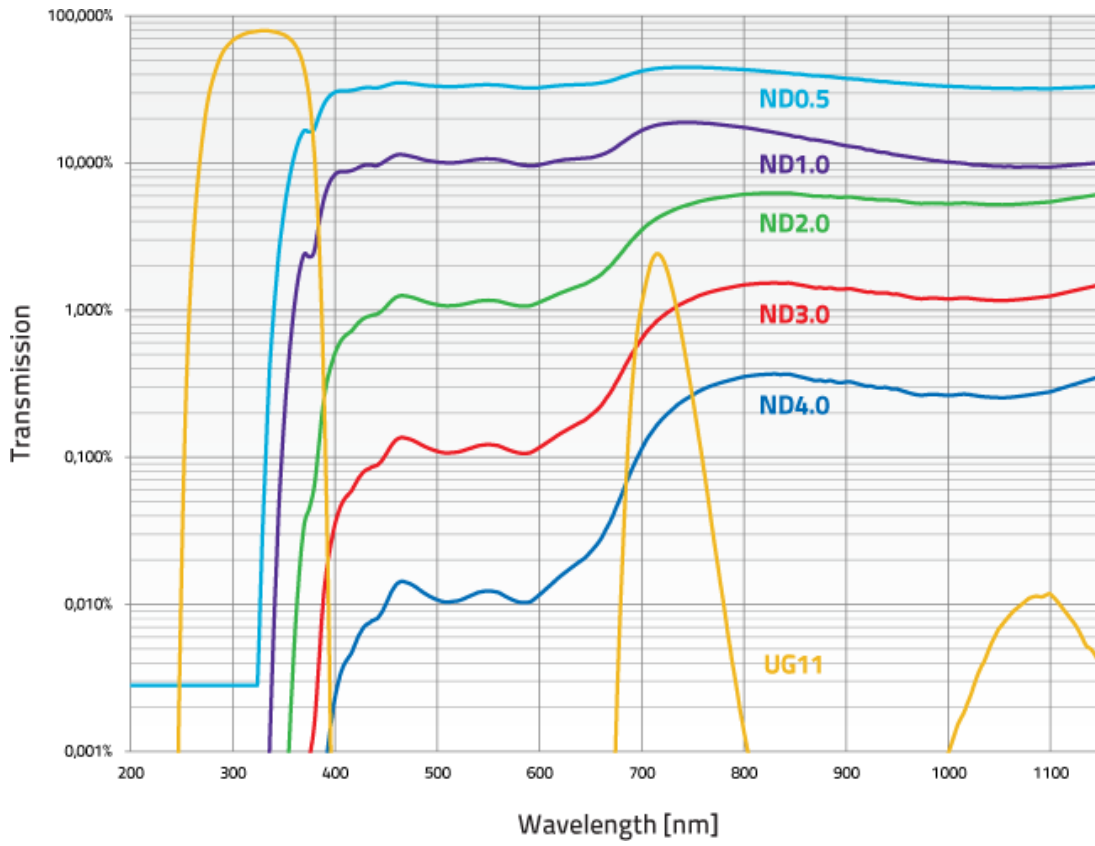
Figure 1-2 Attenuation Filter Transmission

2.　QUICK START PROCEDURE

These steps must be followed in the specified order.

1. Install the PC-Beamage-3.0 software.

2. Install the 11Beamage-3 USB driver by following the 11Beamage-3 Driver Installation Quick Guide (refer to Annex B). The driver must be reinstalled if a new version of software was updated;

    a. If necessary update the 11Beamage-3's firmware, using the BeamageUpdater (refer to Annex C);

3. Connect the 11Beamage-3 to a USB 3.0 port or USB 2.0 port;

    a. If multiple 11Beamage-3 are used, please connect them all to the computer;

4. Start your laser and align in the 11Beamage-3 aperture;

5. Start the PC-Beamage-3.0 software. Select the desired 11Beamage-3 from the displayed list. The green led button in the "*Main Controls*" indicates that communication has been established.

    a. If multiple 11Beamage-3 are used, please start multiple instances of PC-Beamage-3.0 before pressing *"Start Capture";*

6. Press *"Start Capture"*;

7. Let the auto-exposure find the correct exposure time. This should take a few seconds. If the exposure time is at 100 ms and your beam is under exposed, please decrease the ND filter attenuation. If the exposure time is at 0.2 ms and the beam is saturated (maximum is white) please increase the ND filter attenuation;

8. Click on the "*Subtract Background"* in the Ribbon;

9. A message box will appear. Once this message appears, block your laser beam and click *"OK";*

10. Once the *"Please wait"* message box disappears, you can unblock your laser beam;

11. The measures will appear in the *"Home"* tab on the right-hand side;

12. Choose the appropriate graphic for your measurement on the left hand-side:

    a. 3D display;

    b. 2D display;

    c. XY display;

    d. Beam tracking display.

3.   MAIN USER INTERFACE
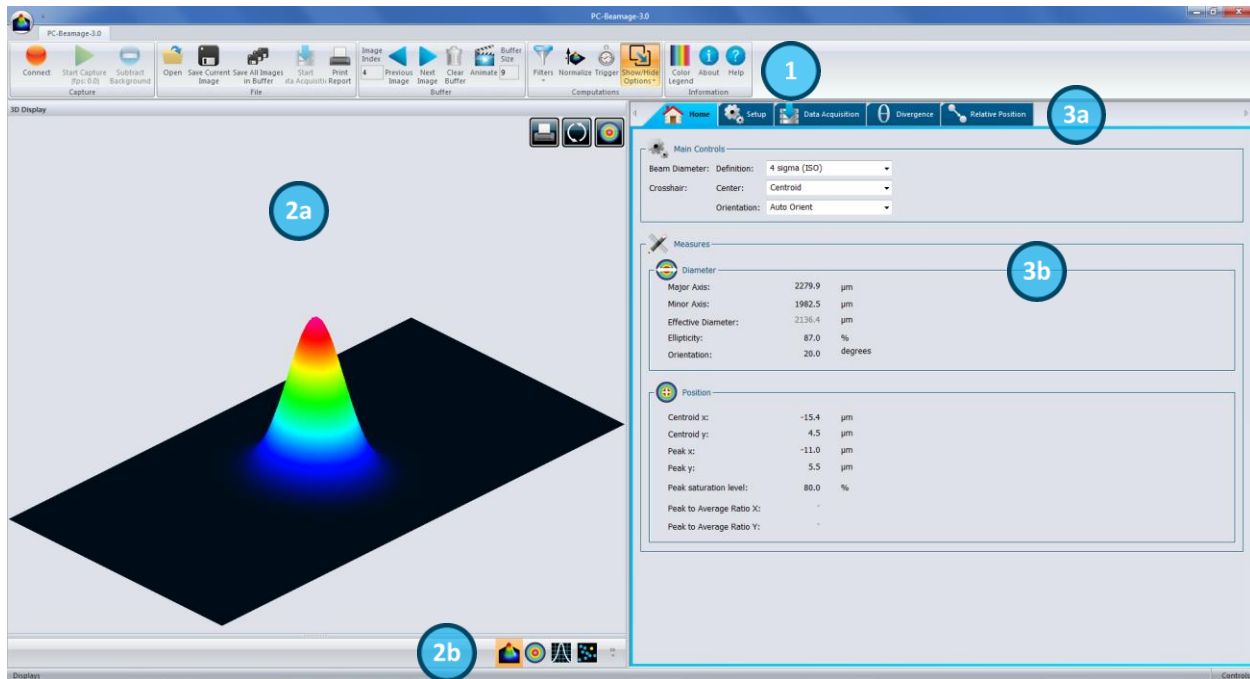
Figure 3-1 PC-Beamage-3.0 User Interface

① **The Main Controls:** The top portion of the software is in a ribbon format and includes all the main controls. These are grouped by family, including *Capture* controls, *File* controls, *Buffer* controls, and *Data Computation* which includes a very useful spatial filter and a normalizing function.

②a **Displays:** The left-hand side of the software is the display panel. Three displays are available: *3D, 2D*, and *XY* (cross-sectional graphs along the crosshairs).

②b **Displays Selector:** At any time, it is possible to change the type of display by selecting the desired graphic (*3D Display, 2D Display, XY Display*).

③a **Analysis Panel - Tab Selector:** Choose between the *Home*, *Setup* or *Data Acquisition* panel tab.

③b **Analysis Panel - Controls:** The right-hand side of the software contains the *Home*, *Setup* and *Data Acquisition* tabs. The first tab (*Home*) allows the user to select the type of measurements to be performed, it also shows the resulting measures of the beam. The second tab (*Setup*) contains all the measurement parameters, such as the *Exposure Time, Image Orientation, Averaging, Active Area,* and more. The third tab (*Data Acquisition*) lets the user specify the desired acquisition parameters.

4.   THE MAIN CONTROLS
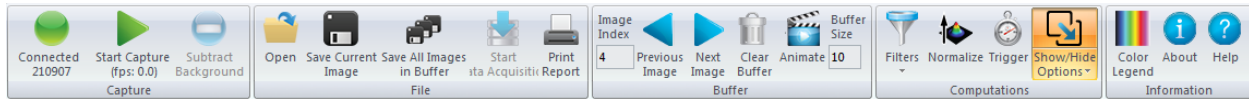
Figure 4-1 PC-Beamage-3.0 Main Controls

To give more room to the graphical display and less to the ribbon, you can minimize the ribbon by right clicking on it and choosing "Minimize the ribbon". You can retrieve the ribbon at any time by right clicking on the upper portion of the window and unchecking "Minimize the ribbon".
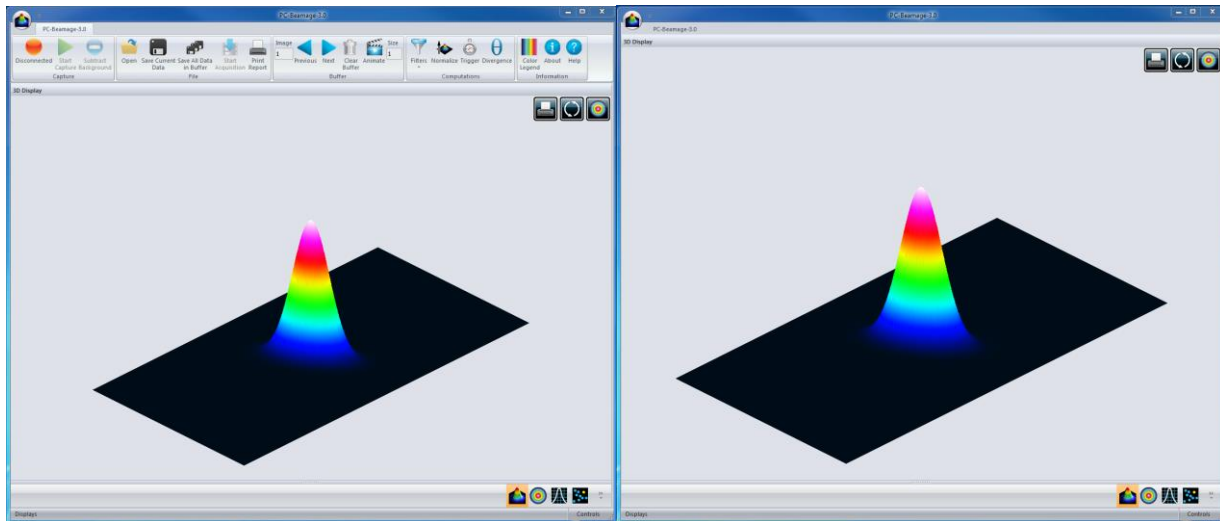
Figure 4-2 The PC-Beamage-3.0 Interface With and Without the Main Controls Ribbon

4.1. MULTIPLE 11BEAMAGE-3 MODE

It is possible to connect multiple 11Beamage-3 to a single computer. When you start the PC-Beamage-3.0 the following window showing all the serial numbers of the connected cameras will appear. If numerous 11Beamage-3 are connected to the computer, please select the desired camera. To connect to another 11Beamage-3 simultaneously, start another PC-Beamage-3.0 instance and select another serial number. You must start streaming after all the desired 11Beamage-3 have been connected to a PC-Beamage-3.0 instance.
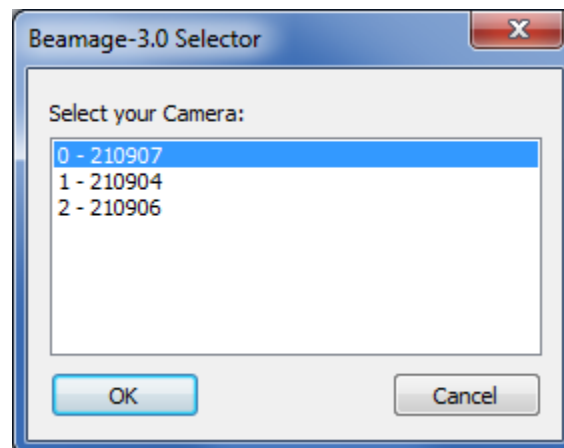
Figure 4-3 11Beamage-3 Selector for Numerous Connected 11Beamage-3

Warning

Multiple 11Beamage-3 beam profilers can be connected to a single computer. However, PC-Beamage-3.0 is not a multiple device software so you need to open a new instance of the program for each camera that is connected to your computer.

4.2. CAPTURE CONTROLS

The *"Capture Menu"* displays the 11Beamage-3 current status, controls the capture, and captures an *average detector background map.*
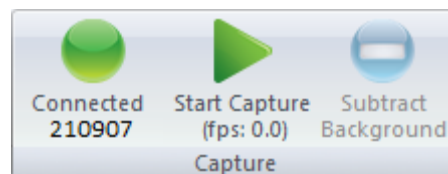
Figure 4-4 Capture Controls

4.2.1. Camera Status
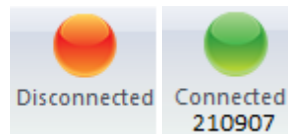
Figure 4-5 Camera Status

The software will automatically detect when a 11Beamage-3 is connected to the computer and it will be indicated in the *Camera Status* with a green button, while a red button indicates that there is no 11Beamage-3 connected. When the PC-Beamage-3.0 is capturing an image, the status green button will flash as well as the LED on the 11Beamage-3. Each time the 11Beamage-3's pixels are capturing an image, the LED will be off to avoid parasitic lighting from the LED. Note that clicking on this button will not do anything since it is not a control button, but rather a status indicator.

4.2.2. Capture Button
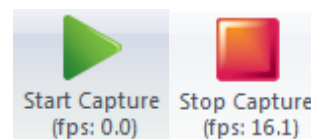
Figure 4-6 Capture Button

To start capturing images with the 11Beamage-3, click on the *"Start Capture"*. If no 11Beamage-3 is connected to the computer or if the *"Animate"* mode (refer to section 4.4.4) is on, this button will not be available. Once the 11Beamage-3 starts streaming, the frame rate will be displayed below the button in frames per second (fps). This measure includes the acquisition and computation time.

4.2.3. Subtract Background Button
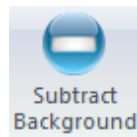
Figure 4-7 Subtract Background Button

Warning

> To abide by ISO-11146-3:2004 (Section 3) and have an accurate measurement, a background subtraction must be done.

Once you have clicked the *"Subtract Background"* button, the following message box will appear:
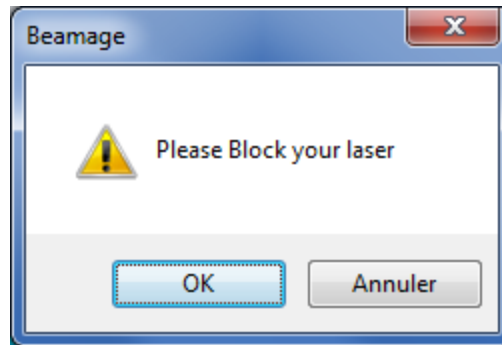
Figure 4-8 Subtract Background Message Box

Once this message box appears, block the beam and then click on *"OK"*. The software will capture 10 images and average pixel by pixel to compute the *average detector background map.* A *"Please Wait"* message box will appear while the software is capturing the *average detector background map.* The *detector background map* will be subtracted from all the images that will follow. Note that once the background subtraction has been done, the exposure time will no longer be in *"Auto"* mode and set to the current exposure time.

Tip

> Be sure to block your beam only when the Message Box appears and not before.

4.3. FILE CONTROLS

The *"File Menu"* opens and saves frames captured with the 11Beamage-3, and also prints a complete report.
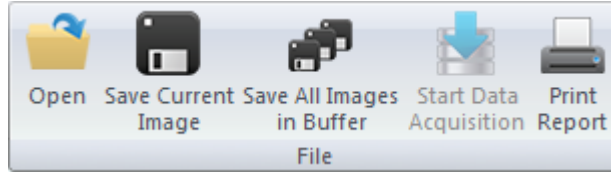
Figure 4-9 File Controls

4.3.1. Open
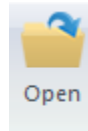
Figure 4-10 Open File Button

Click on the *"Open"* file button to retrieve previously saved data. The PC-Beamage-3.0 software will only open native *.BMG files. The files can contain between 1 and 32 frames, depending on how the file was created (refer to section 4.3.2 and 4.3.3). If the file was saved with multiple frames, it will be possible to access all of them with the *Buffer Control* (refer to section 4.4).

4.3.2. Save Current Image
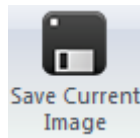
Figure 4-11 Save Current Image Button

Click on the *"Save Current Image"* button to save the currently displayed image. This option will only save 1 frame. Data can be saved in native *.BMG format, in text *.TXT format or in binary *.BIN format. Note that only the *.BMG format can be re-opened with the PC-Beamage-3.0 software.

The *.TXT and the *.BIN files must be used with a compatible software. The *.TXT file saves a header containing the measurements settings followed by the sensor's output matrix. Every pixel output is separated by a coma. The *.BIN file only saves the data and does not contain a header. The .*bin file saves data on signed 32 bit integers.

4.3.3. Save All Images in Buffer
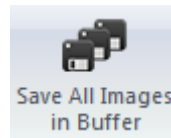
Figure 4-12 Save All Images in Buffer Button

Click on the *"Save All Images in Buffer"* button to save all the frames stored in the buffer. Data can be saved in native *.BMG format, in text *.TXT format or in binary *.BIN format. Note that only the *.BMG format can be re-opened with the PC-Beamage-3.0 software. When opening the *.BMG file, all the stored images will be accessible via the *Buffer Controls* menu including all the calculated measurement values (refer to section 4.4).

When saving in *.TXT or *.BIN file, a series of files will be saved and identified with their respective buffer index number. The *.TXT and the *.BIN files must be used with a compatible software. The *.TXT file saves a header containing the measurements settings followed by the sensor's output matrix. Every pixel output is separated by a coma. The *.BIN file only saves the data and does not contain a header. The .*bin file saves data on signed 32 bit integers.

4.3.4. Start Data Acquisition
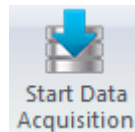
Figure 4-13 Start Data Acquisition Button

Click on the *"Start Data Acquisition"* button to start the data logging of all the measurements displayed in the "*Home*" tab. This function is only available while the camera is streaming. The acquisition parameters can be modified in the "*Data Acquisition*" tab on the right-hand side of the user interface (refer to section 5.3).

It is only possible to save the beam profiling results shown in the measure tab (refer to section 5.1.2) in a *TXT file. The *TXT file includes a header, containing the acquisition settings, followed by the data. Each line corresponds to a single frame and all the measurements are separated by a tab. This file can be opened in a spreadsheet software, such as Microsoft Excel.

It is also possible to save the images associated with the measurements saved in the *.TXT logging file. Each image will be individually saved in a native *.BMG file. Each file will have the same filename as the *.TXT file, followed by the corresponding increment.

 Warning

Each *.BMG file can take up to 8.50 MB on the hard drive. Acquiring multiple frames can quickly sum up to multiple GigaBytes.

Fast acquisition should only be done on the computer's hard drive and cannot be done on an external drive or on a server hard drive.

4.3.5. Print Report
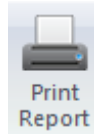
Figure 4-14 Print Report Button

Click on the *"Print Report"* button to print a complete report of the current measurement. A print preview will appear in the PC-Beamage-3.0 software. To print the report, click on "Print". To exit without printing, click "Exit". The buttons are located on the right-hand side.
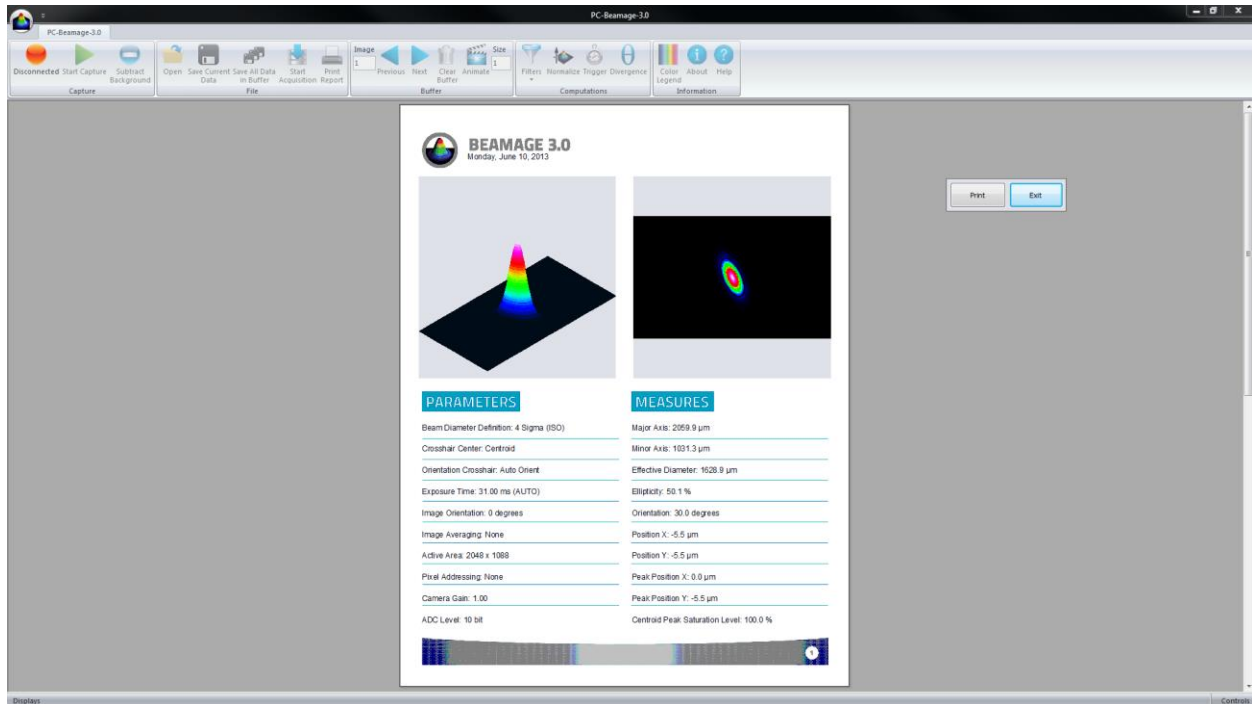
Figure 4-15 Print Report Preview

The report fits on 2 pages. The first page presents the 3D and 2D images, measurement results, and the 11Beamage-3's settings.

BEAMAGE 3.0
Tuesday, March 12, 2013
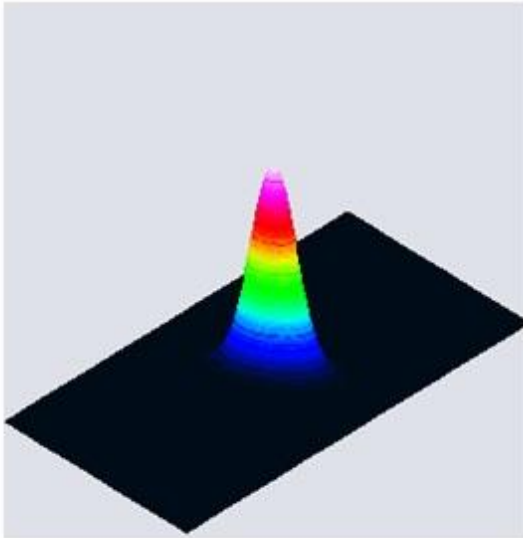
PARAMETERS

Beam Diameter Definition: 4 Sigma (ISO)

Crosshair Center: Centroid

Orientation Crosshair: Auto Orient

Exposure Time: 31.00 ms (MANUAL)

Image Orientation: 0 degrees

Image Averaging: None

Active Area: 2048 x 1088

Pixel Addressing: None

Camera Gain: 1.00

ADC Level: 12 bit

MEASURES

Major Axis: 2109.3 µm

Minor Axis: 1054.7 µm

Effective Diameter: 1667.6 µm

Ellipticity: 50.0 %

Orientation: 30.0 degrees

Position X: 269.5 µm

Position Y: 49.5 µm

Peak Position X: 269.5 µm

Peak Position Y: 44.0 µm

Centroid Peak Saturation Level: 100.0 %

Figure 4-16 Print Report Page 1

The second page prints the cross-sectional XY graphs along the crosshairs. If the *"Cursor"*, the "*Gaussian Fit"*, *"FWHM", or the "1/e^2"* options are selected (refer to section 6.3.1), they will also appear in the report.
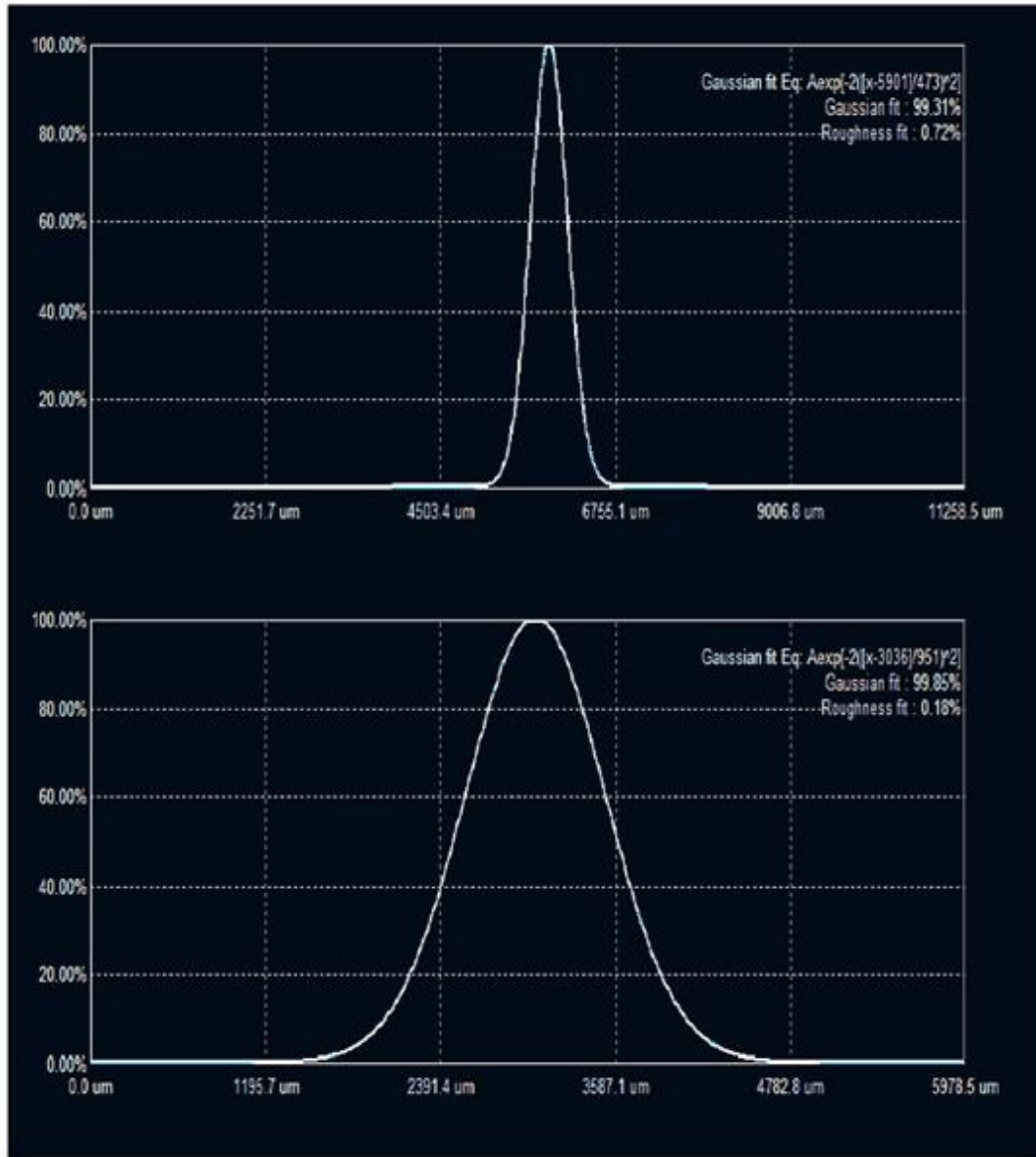
Figure 4-17 Print Report Page 2

4.4. BUFFER CONTROLS

The PC-Beamage-3.0 software saves the last 32 frames in the buffer. This buffer is circular, the first stored frame is replaced by the last taken image. The buffer can store from 1 to 32 frames. By default, the buffer size is 10.
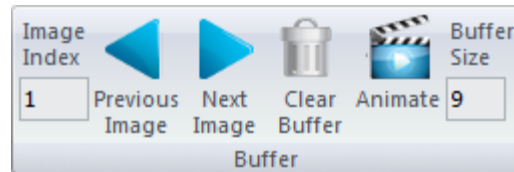
Figure 4-18 Buffer Controls

Warning

Note that all images are stored in the RAM memory of your computer, which could limit the number of images in the buffer.

4.4.1. Image Index
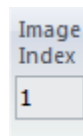
Figure 4-19 Image Index

The *"Image Index"* edit box displays the current image index. When the 11Beamage-3 is not streaming, it is possible to access different frames by typing the desired image index.

4.4.2. Previous Image and Next Image
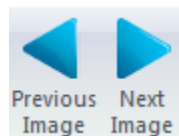
Figure 4-20 Next and Previous Image Buttons

The *"Next Image"* and *"Previous Image"* buttons access the next and previous image in the buffer.

4.4.3. Clear Buffer
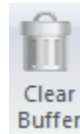
Figure 4-21 Clear Buffer Button

The clear buffer button clears the entire buffer. The captured frames will no longer be available, any measures and graphical displays will also be erased.

4.4.4. Animate
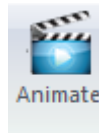
Figure 4-22 Animate Button

Once the 11Beamage-3 has captured frames in its buffer, it is possible to stream them in a playback manner. With as much as 32 frames temporarily saved in the buffer, simply clicking the animation button will create an animation with any display (2D, 3D, and XY). This allows to visualize the beam while working offline and to have a recalculation process if the beam diameter definition or crosshair parameters are changed.

4.4.5. Buffer Size
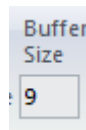
Figure 4-23 Buffer Size

The *"Buffer Size"* edit box displays the number of images stored in the buffer. It is possible to change the buffer size from 1 to 32 images.

4.5. DATA COMPUTATIONS

The *"Data Computations"* menu filters and normalizes the current frame and enables the 11Beamage-3's trigger and divergence options.
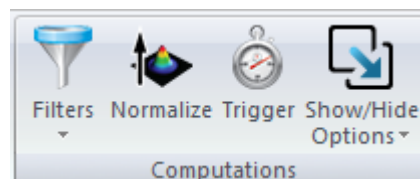
Figure 4-24 Data Computations

4.5.1.Filters
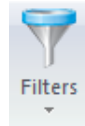
Figure 4-25 Filters Button

The "*Filters*" button opens a drop-down menu. Two spatial filters are available: "*Smoothing*" and "*Despeckle*". This tool is great with low quality laser or low level signals. Note that this filter is more "aggressive" than the *"Smoothing"* filter, which makes it ideal for very poor quality beams.
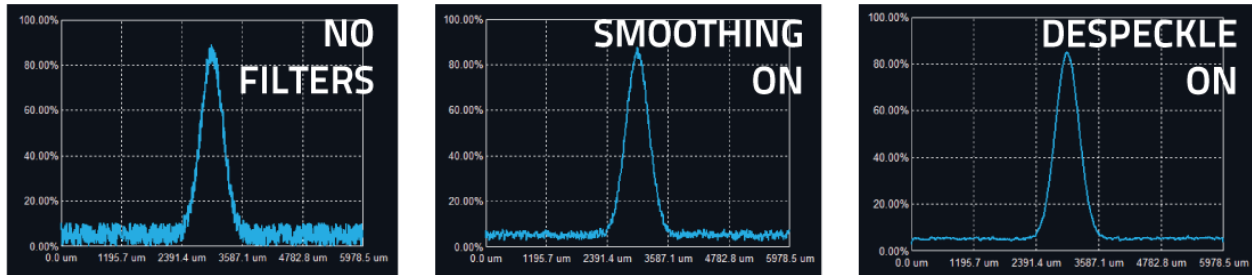
Figure 4-26 Spatial Filter Example

  Warning

If an image is saved while it is in "*Filter*" mode, the resulting filtered image will be saved

Smoothing Filter

The *"Smoothing"* filter performs a 3x3 mask triangular filter. The center pixel has a higher weight (2/10) than the surrounding pixels (1/10). If the filtered pixel is on the edge, it will set the surrounding pixels outside the image to 0.

Despeckle Filter

The *"Despeckle"* filter uses a 9x9 mask flat filter to perform a simple averaging of the central pixel. All pixels have the same weight (1/81). If the filtered image is on the edge, the surrounding pixels outside the image will be set to 0.

4.5.2. Normalize
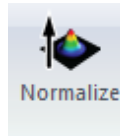
Figure 4-27 Normalize Button

The *"Normalize"* button will spread the graph's (3D, 2D, and XY) intensity over the full range (0% to 100%). Note that only the displays are normalized, the normalization does not affect the centroid and diameter computations.
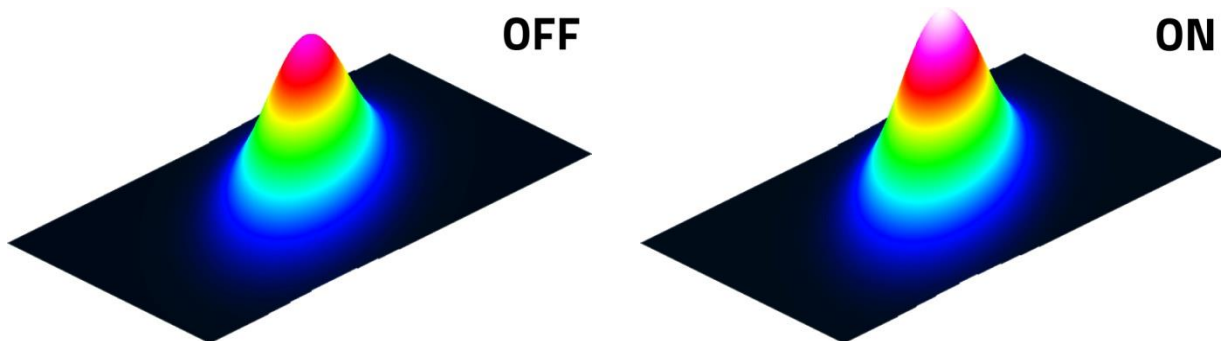
Figure 4-28 Normalization Example

4.5.3. Trigger
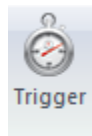
Figure 4-29 Trigger Button

The *"Trigger"* button enables the camera to capture images only when an electric signal is sent to the 11Beamage-3 via the SMA connector. This can synchronize the system's capture rate with a pulsed laser source. A SMA to BNC adaptor is provided (202273). The input trigger signal can be from 1.1 volts to 24 volts. The rise edge response time is 300 ns. The pulse width of the trigger signal must be between 300 ns and 230 ms.

SMA Connector

Figure 4-30 SMA Connector for Trigger Input

4.5.4. Show/Hide Options
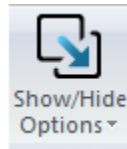
Figure 4-31 Show/Hide Options Button

The "*Show/Hide Options*" button will show or hide the "*Divergence*", the "*Relative Position*" and "Camera Lens Calibration" panels beside the "*Data Acquisition*" tab. By clicking on "*Show All' or "Hide All"*, one can show or hide both tabs at the same time.
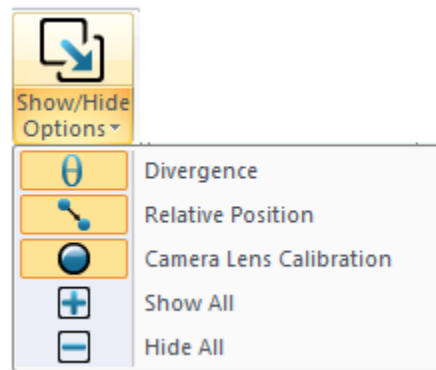
Figure 4-32 Show/Hide Options

4.5.4.1.   Divergence
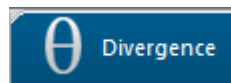
Figure 4-33 Divergence Button

The "*Divergence*" button activates a new tab on the right-hand side of the user interface. It contains all the settings and results relative to the beam divergence (refer to section 5.4). To compute the divergence and abide by the ISO-11146-1:2005 standard, the first step is to place an aberration-free lens between the 11Beamage-3 and the laser. The lens should be placed in the far-field of the laser beam while the 11Beamage-3 should be at the focal point of the lens. The second step is to enter the focal length of the lens in the software. Since the focal length is wavelength dependent, make sure to use the correct value for your laser in the settings. The divergence in both main axes (x and y) are computed as defined by the ISO-11146-1:2005 and ISO-11146-2:2005 standards and displayed at the bottom of the "*Divergence"* tab.

 Warning

The 11Beamage-3 sensor must be placed precisely at the focal point, not at the beam waist.

4.5.4.2.   *Relative Position*
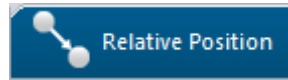
Figure 4-34 Relative Position Button

The "*Relative Position*" button activates a new tab on the right-hand side of the user interface. It contains all the settings and results relative to the origin position and the camera lens calibration. This tool allows you to easily align a laser to any desired position. Please refer to section 5.5 for more information about this functionality.

4.6. SOFTWARE INFO

The "*Information Menu*" displays important and useful information about the 11Beamage-3 and provides help.
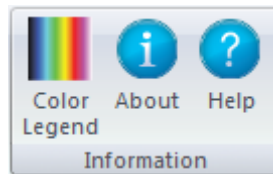
Figure 4-35 Software Info

4.6.1.Color Legend
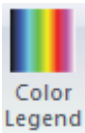
Figure 4-36 Color Legend Button

The *"Color Legend"* button shows the colors corresponding to the 3D and 2D display intensity levels.

Figure 4-37 Color Legend

4.6.2. About

Figure 4-38 About Button

To learn more about the PC-Beamage-3.0 software, camera and sensor, click the "*About"* Button.

Tip

You can also obtain the latest PC-Beamage-3.0 software version on our
website

4.6.3. Help
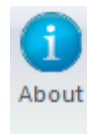
Figure 4-39 Help Button

The "*Help"* button opens the 11Beamage-3 user manual. All information, tips, warnings and troubleshooting about the software are in this manual.

Warning

The help file is in PDF format. A PDF reader needs to be installed on your PC to open the file.

5.   HOME AND SETUP PANELS

The PC-Beamage-3.0 offers different panels to view the measures and set different options for the 11Beamage-3.

Home: Controls the computation parameters and displays the beam's diameter and centroid information.

Setup: Controls the 11Beamage-3 parameters.

Data Acquisition: Controls the acquisition parameters

Divergence: Controls the divergence parameters and displays the results. This tab is available when the *Divergence* button is activated in the *Main Controls* (refer to section **4.5.4**).

Relative Position: Sets the origin position (0,0) to a user defined value and calibrates the Pixel Magnification Factor. This tab is available when the *Divergence* button is activated in the *Main Controls* (refer to section **4.5.4**).

Camera Lens: Calibrates the Pixel Multiplication Factor when using a Camera Lens. This tab is available when the *Divergence* button is activated in the *Main Controls* (refer to section **4.5.4**).

To choose the desired display mode, click on the corresponding tab above the Controls and Measure panel
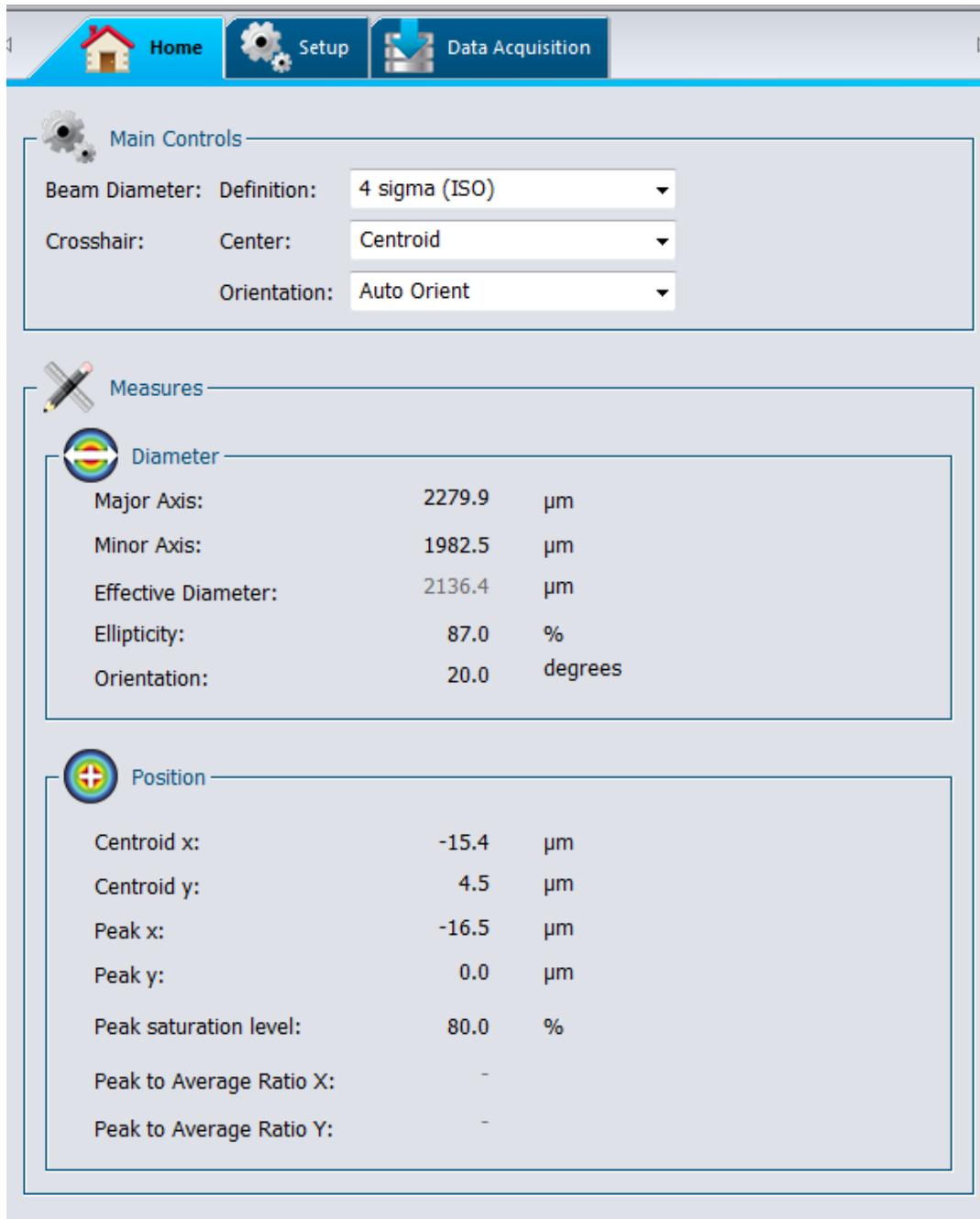
Figure 5-1 Graphic Display

5.1. HOME

Figure 5-2 Home Tab

Main Controls: Defines the beam width definition and crosshair position.

Diameter: Displays the beam diameter computation results.

Centroid: Displays the beam's centroid and peak coordinates.

5.1.1.Main Controls

The "*Main Controls"* section allows the user to set the desired beam diameter definition and crosshair position. Use the drop-down menu to select the desired setting.

5.1.1.1.   Beam Diameter Definition

By default, the beam width definition is set to "*4 sigma (ISO)"* which respects the ISO-11146-1:2005 and ISO11146-2:2005 standards (refer to Annex A ISO11146 and iso11670 Definitions). This definition takes the entire image to compute the beam parameters slowing the computation time and reducing the frame rate.

The "*FWHM along crosshairs (50%)"* finds the crosshair's Full Width Half Maximum (FWHM). The algorithm will return the width corresponding to the curve's first half maximum and the curve's last half maximum. Because the beam definition only takes into account a slice of the beam, the computation time is much faster and higher frame rates can be achieved.

The "*1/e2 along crosshairs (13.5%)"* finds the crosshair's width corresponding to $1/e^2$ (about 13.5%) of its maximum. Similarly to the FWHM, this beam definition will increase the frame rate.

The "*86% effective diameter (D86)"* computes the circular beam containing 86% of the total intensity. This definition assumes the beam is circular.

5.1.1.2.   Crosshair Definition

The crosshair is defined by its center (intersection of the 2 crosshairs) and its orientation. The crosshair center can be set to the beam's centroid as defined by the ISO-11146-1:2005 and ISO-11146-2:2005 standards or the beam's peak position. If many pixels correspond to the peak value, the crosshair's center will be set to the first peak.

The crosshair's orientation is set to "*Auto Orient"* by default, which aligns it to the beam's orientation as defined by the ISO-11146-1:2005 and ISO-11146-2:2005 standards. It can also be set to a fixed 45° or 0° angle.

 Warning

> The crosshair definition will affect the XY Display (refer to section 6.36.3) and the beam width if it is defined by the FWHM or $1/e^2$ along crosshair

5.1.2.Measure

The "*Measure"* section presents the beam's diameter and centroid information according to the selected beam definition (refer to section 5.1.1.1).

The computation algorithm first determines an approximate beam diameter (13.5% clip level). The algorithm will consider that all pixels outside 2 times the approximate beam diameter are the *outside area*. The *outside area's* average will become the *baseline*, which will be subtracted from the *area containing the beam*. Only the *area containing the beam* will be used to compute the diameter. This means that a smaller beam will have a smaller area which will decrease the computation time and increase the frame

rate. If the beam is larger and all pixels contain the *area containing the beam*, there will be no *baseline* subtraction and the frame rate will be slower.

5.1.2.1.   Diameter

The *"Major Axis"* is the beam maximum width whereas the "Minor Axis" is the minimum beam width.

The "Effective Diameter" is the beam's diameter considering it is circular.
The effective diameter is only valid if the ellipticity is greater than 87%. If the beam's ellipticity is lower than 95%, the effective diameter will by greyed-out, indicating it is not valid.

The *"Ellipticity"* is the ratio between the minor axis and the major axis. For a perfect round Gaussian beam, the ellipticity would be equal to 100%.

The *"Orientation"* is defined as the "angle between the *x-axis* […] and that of the principal axis of the power density distribution which is closer to the *x-axis."* [1]. From this definition, the angle is comprised between -45° and 45°.

For more information on beam diameter computations as defined by the ISO-11146-1:2005 and ISO-11146-2:2005 standards, please refer to Annex A ISO11146 and iso11670 Definitions)

⚠ Warning

According to the beam definition, the displayed measures will vary. For example, for a 86% effective diameter, only the effective diameter will be displayed, as the major, minor axis, and orientation are not relevant in a perfectly circular beam.

5.1.2.2.   Centroid

All positions are relative to the image center which is (0,0). The horizontal axis increases towards the right-hand side and the vertical axis increases towards the top.
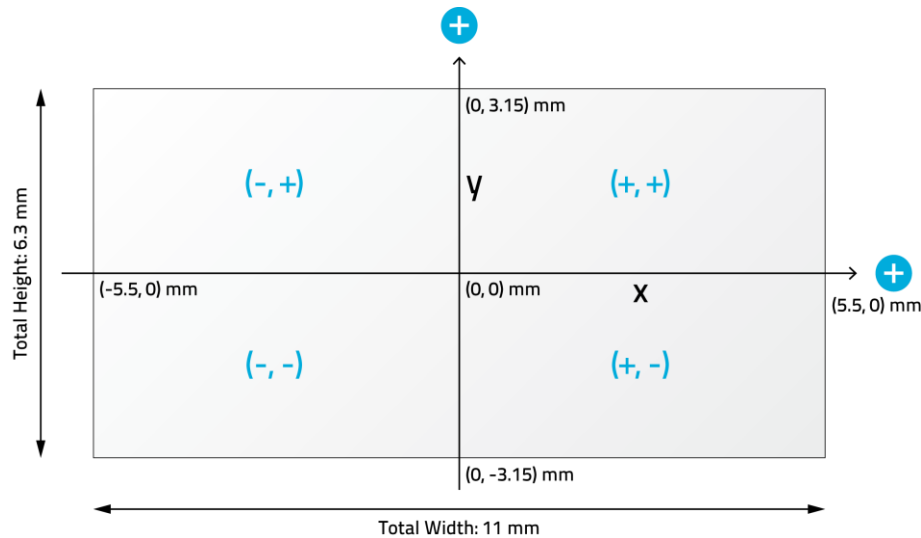
Figure 5-3 Fixed Coordinates System for the Sensor

---

[1] International Organization for Standardization, *ISO 11146 :2005 Laser and laser-related equipment – Test methods for laser beam widths, divergence angles and beam propagation ratios, 2005, Geneva*

The beam *"Centroid"* corresponds to the beam's first order distribution as defined by the ISO-11146-1:2005 and ISO-11146-2:2005 standards (refer to Annex A)

The beam's *"Peak"* position corresponds to the pixel's peak value position. If many pixels correspond to the peak value, the crosshair will be centered on the first peak.

The beam *"Peak to Average Ratio"* corresponds to the ratio between the actual beam peak value and the height of an equivalent simulated flat-top beam. The simulated beam's width is the $1/e^2$ diameter of the actual beam and has the same area (same energy). The software computes the ratios for both the X and Y axes.

Normalized Experimental Beam (100%)

Theoretical Flat-Top Beam

$1/e^2$ (13.5%)

Area of the Normalized Beam

Area of the Theoretical Flat-Top

=

Figure 5-4 Peak to Average

These results are only available when the *"1/e2 along crosshairs (13.5%)"* beam diameter definition is selected. If any other definition is used, the *"Peak to Average Ratios"* are not computed and dashes are displayed. When the crosshair center is set to *"Centroid"* instead of *"Peak"*, results are grayed out to remind the user that the values do not correspond to the *"Peak to Average Ratios"*.

Centroid		
Centroid x:	-5.5	μm
Centroid y:	-5.5	μm
Peak x:	0.0	μm
Peak y:	-5.5	μm
Peak saturation level:	100.0	%
Peak to Average Ratio X:	1.674	
Peak to Average Ratio Y:	1.672	

Figure 5-5 Peak to Average Ratio Example

5.2. SETUP

The *"Setup"* tab allows the user to set the 11Beamage-3 parameters.
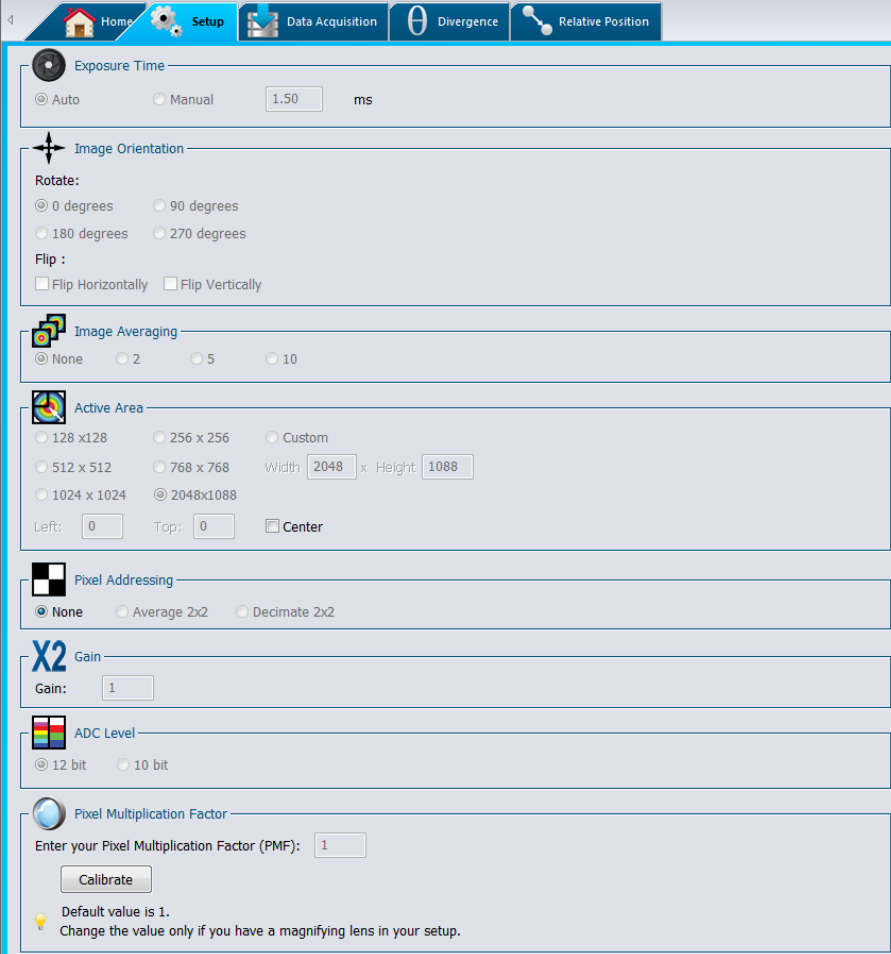
Figure 5-6 Setup Tab

Exposure time: Controls the 11Beamage-3 sensor's exposure time.

Image orientation: Rotates or flips the captured image.

Image Averaging: Applies a temporal filter by averaging multiple frames

Active Area: Selects the region of interest.

Pixel Addressing: Reduces the spatial resolution by averaging or decimating pixels.

Gain: Adds numerical gain to captured image.

ADC Level: Selects the BEAMAGE's ADC level for each pixel

Pixel Multiplication Factor: Adjusts the pixel multiplication factor when using optical components

5.2.1. Exposure Time

The *"Exposure Time"* controls the 11Beamage-3's exposure time settings. It can be set from 0.2 ms to 100 ms. The *"Auto"* option will automatically set the exposure time in order to have the maximum beam intensity at 85% of the sensor's saturation level. The exposure time can also be set manually by clicking on the corresponding radio button and changing the value in ms.

Tip

> If the beam is still saturated at a 0.2 ms exposure time, please increase the attenuation in front of the 11Beamage-3. If the beam intensity is too low at 100 ms exposure time, please lower the attenuation in front of the 11Beamage-3.

5.2.2. Image Orientation

The *"Image Orientation"* controls rotate or flip the captured frame. The captured frame can be rotated to 90°, 180°, or 270°. All angles rotate clockwise. The captured frame can also be flipped horizontally or vertically. If a frame is saved with a rotation and/or a flip, it will keep these orientation settings. Note that the reference axis for the centroid is neither flipped nor rotated. All positions are always relative to the image's center which is (0,0) and the horizontal axis always increases towards the right-hand side and the vertical axis always increases towards the top.
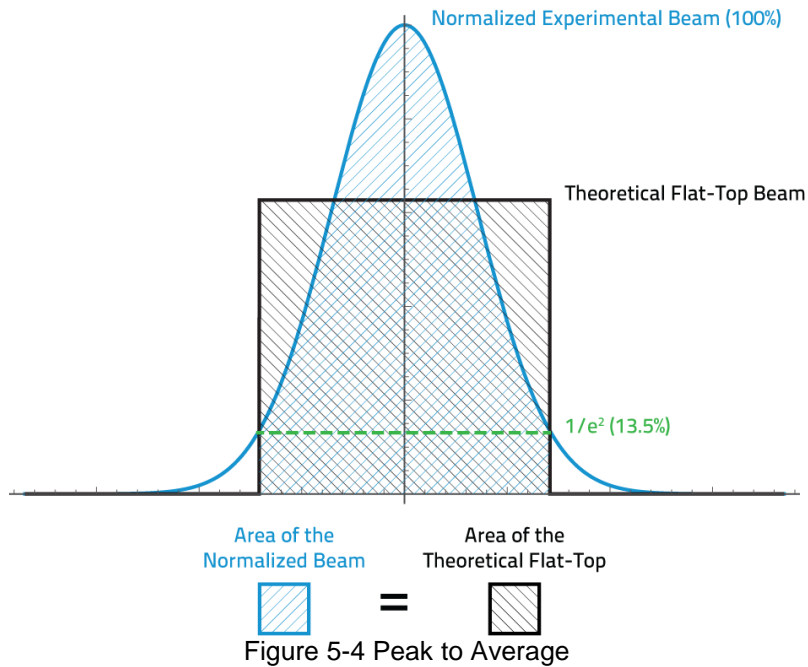
Warning

> The image orientation is only valid on captured images. When the 11Beamage-3 is not capturing images and is in *"Animate"* mode or buffer viewing mode, it will neither flip nor rotate the current image, as it has already been captured.

5.2.3. Image Averaging

The *"Image Averaging"* function is a temporal filter that captures a specified number of frames (2, 5, or 10) and averages the frames pixel by pixel to create a single time-averaged image. This lowers the total frame rate because multiple frames need to be captured for one computation.

Tip

> The *Image Averaging* process will smooth the beam's fluctuations that can occur over time. It is very useful when working with unstable laser sources.

5.2.4.Active Area

The *"Active Area"* function allows the user to select a region of interest (ROI) on the sensor. This will increase the frame rate, as fewer pixels need to be transferred from the 11Beamage-3. This can only be done on small beam sizes, since a cropped beam would invalidate the beam width measurements. Furthermore, to have an accurate measurement, the active area must be at least 2 times the beam size.

The user can select the desired area from a preset selection or enter a custom size. By default, the area will be placed at the sensor's upper left corner pixel (0, 0). This position can be changed by entering the active area's upper left position. Checking the "*Center*" check box will center the active area to the sensor's center.

Tip

> **When working with small beams,** optimize the speed of the data transfer and still maintain accurate results, by using an *Active Area* that is twice the size of your beam.

5.2.5.Pixel Addressing

The *"Pixel Addressing"* mode allows the user to downsample the captured image. The *"Average 2x2"* will take a 2x2 pixel cluster and return its average as one larger pixel. The "Average 2x2" function is only available in the 12 bit ADC mode. The *"Decimate 2x2"* will only return 1 out of the 4 pixels. Because the pixel area is doubled with this mode, it can be used with large beams, where the spatial resolution is not crucial. It will increase the frame rate because fewer pixels are transferred from the 11Beamage-3.

| Full Resolution | Average 2x2 | Decimate 2x2 |
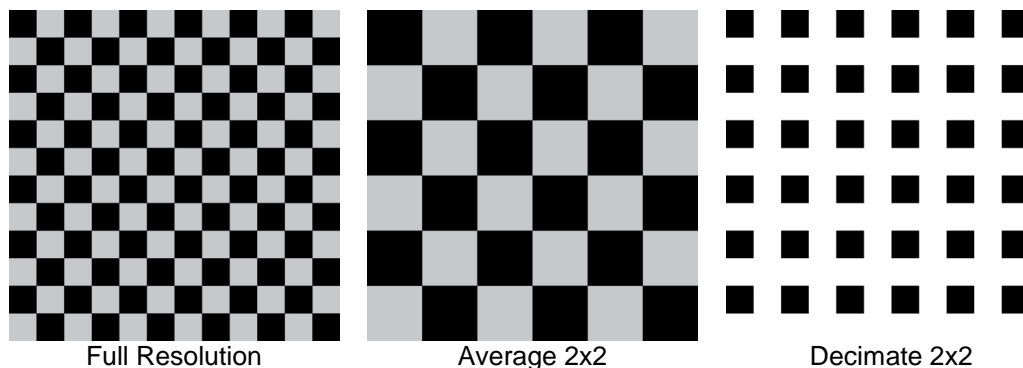
Figure 5-7 Pixel Addressing Mode

Tip

> **When working with large beams,** optimize the speed of the data transfer by reducing the spatial resolution using the *Pixel Addressing* function.

5.2.6. Gain

The *"Gain"* setting allows the user to set a numerical gain on the captured image. The gain must be between 1 and 10. If the pixel value is over the maximum ADC level (For 12-bit → 2^{12} = 4096), the pixel value will be topped at the maximum ADC level.

5.2.7. ADC Level

The ADC level is the pixel's depth which can be set to 12 or 10 bit. In the 12 bit mode, each pixel value is on 2^{12} = 4096 levels while the 10 bit mode is on 2^{10} = 1024 levels. The 12 bit mode has a slower frame rate.

Warning

If the 11Beamage-3 is set in 12 bit mode, it will slow the frame rate.

5.2.8. Pixel Multiplication Factor (PMF)

If the 11Beamage-3 camera is operated with an optical component that has magnification properties (such as a magnifying lens, a UV Converter or an IR Adaptor), the Pixel Multiplication Factor must be adjusted in order to have the exact beam dimensions. The *"Pixel Multiplication Factor"* section can be found at the bottom of the *"Setup" tab.*

Tip

The default value for the Pixel Multiplication Factor is 1.

Pixel Multiplication Factor

Enter your Pixel Multiplication Factor (PMF): 1

Calibrate

Default value is 1.
Change the value only if you have a magnifying lens in your setup.

Figure 5-8 Pixel Multiplication Factor

It is possible to manually set a value for the PMF. Simply enter the desired value in the white box and press enter. The beam dimensions will be adjusted accordingly. If a camera lens is used with the 11Beamage-3 camera, it is possible to follow the camera lens calibration steps by clicking on the *"Calibrate"* button. This will open the *"Camera Lens"* tab. Refer to section 5.6 for more information about the camera lens calibration

5.3. DATA ACQUISITION

The *"Data Acquisition"* tab allows the user to set the acquisition parameters. It is possible to save the beam profiling results shown in the measure tab (refer to section **5.1.2**) in a *TXT file. The *TXT file includes a header, containing the acquisition settings, followed by the data. Each line corresponds to a single frame and all the measurements are separated by a tab. This file can be opened in a spreadsheet software, such as Microsoft Excel. It is also possible to save the images associated with the measurements saved in the *.TXT logging file. Each image will be individually saved in a native *.BMG file.

Camera Name: PC-Beamage-3.0
Serial Number: 208111
Firmware: 1.7
Description: PC-Beamage-3.0
Sample Rate: 1 / 1 pulse(s)
Total Duration: 0:0:0:15 (DD:HH:MM:SS)

Date	Ellapsed time(sec)	Major Axis(um)	Minor Axis(um)	Effective Diameter(um)	Ellipticity(%)	Orientation(degrees)	Centroid X(um)	Centroid y(um)	Peak X(um)	Peak Y(um)	Peak Saturation	Peak to Average Ratio X	Peak to Average Ratio Y
09:43:39, Thursday, June 13, 2013	0.421	2666.7	1281.5	2092.1	48.1	29.5	-141.2	977.1	-159.5	858	93.9	2.8	2.4
09:43:39, Thursday, June 13, 2013	0.874	2666.6	1281.5	2092	48.1	29.5	-141.9	977.1	-462	880	89.7	2.8	2.4
09:43:40, Thursday, June 13, 2013	1.466	2667	1282.6	2092.6	48.1	29.5	-141.2	978	-462	880	90.5	2.8	2.4
09:43:40, Thursday, June 13, 2013	1.919	2666.4	1282.2	2092.1	48.1	29.5	-141.8	976.9	-170.5	858	92.4	2.8	2.4
09:43:41, Thursday, June 13, 2013	2.371	2666.1	1281.2	2091.6	48.1	29.5	-141.3	976.1	-456.5	880	95.1	2.8	2.4
09:43:41, Thursday, June 13, 2013	2.808	2669.3	1285.3	2094.9	48.2	29.6	-140.2	978.9	-198	858	93	2.8	2.4
09:43:42, Thursday, June 13, 2013	3.26	2668.2	1284.6	2094	48.1	29.4	-140.6	977.7	-462	880	95.8	2.8	2.4
09:43:42, Thursday, June 13, 2013	3.713	2667.3	1282.5	2092.8	48.1	29.4	-141.8	976.7	-165	858	91.3	2.8	2.4
09:43:43, Thursday, June 13, 2013	4.165	2667.6	1283.3	2093.2	48.1	29.4	-141.9	976.9	-198	858	91.7	2.8	2.4
09:43:43, Thursday, June 13, 2013	4.618	2668	1283.8	2093.6	48.1	29.5	-141.3	977.1	-170.5	869	93.4	2.8	2.4
09:43:44, Thursday, June 13, 2013	5.07	2669.2	1287.1	2095.4	48.2	29.4	-141.1	977.5	-170.5	858	92.5	2.8	2.4
09:43:44, Thursday, June 13, 2013	5.522	2667.7	1283.3	2093.3	48.1	29.4	-141.4	976.7	-170.5	858	94.3	2.8	2.4
09:43:45, Thursday, June 13, 2013	5.975	2668.7	1285.5	2094.5	48.2	29.5	-141.6	977.3	-159.5	869	92.9	2.8	2.4
09:43:45, Thursday, June 13, 2013	6.443	2670	1286.4	2095.6	48.2	29.4	-140.6	978	-462	880	92.7	2.8	2.4

Figure 5-9 Example File of a Measurement Acquisition

To start the acquisition, click on the "Start Data Acquisition" button in the "Main Controls" (refer to section 4.3.4).
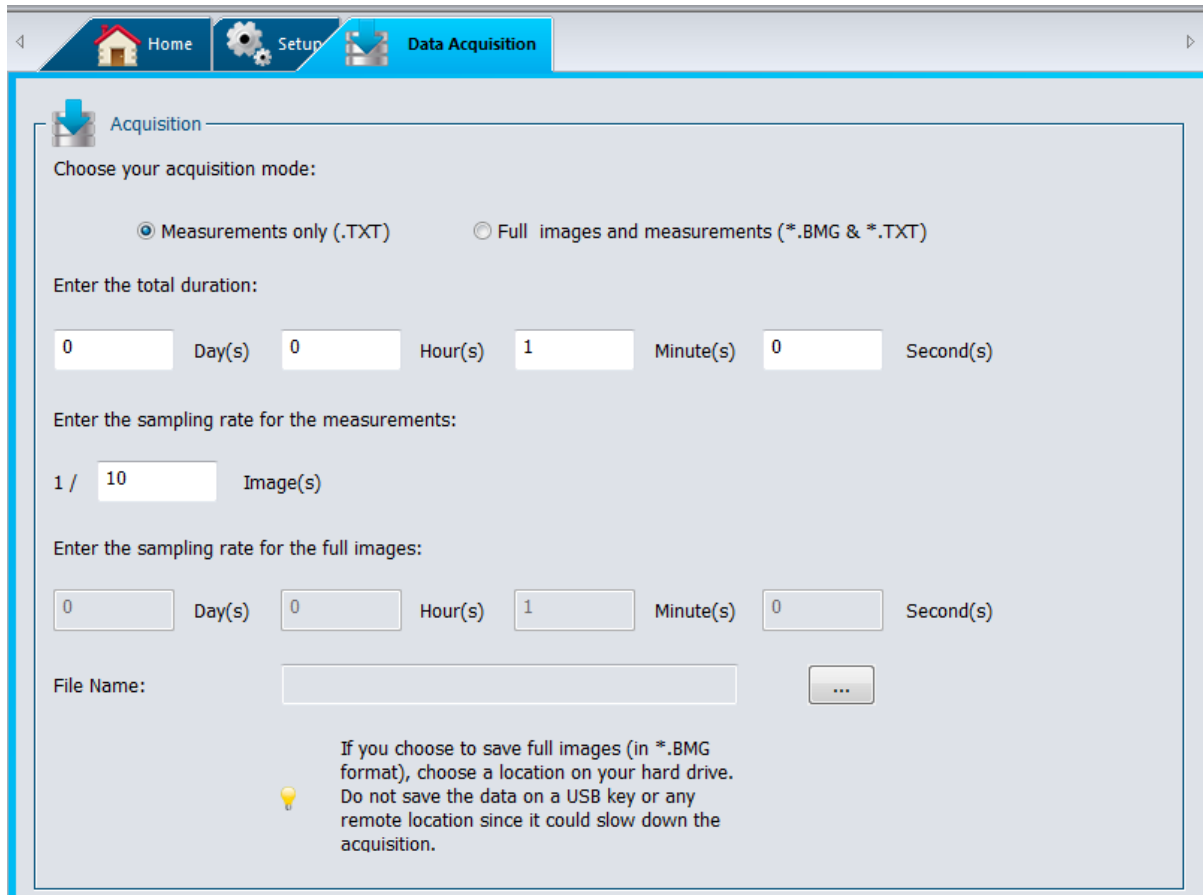
Figure 5-10 Data Acquisition Tab

The *"Duration"* defines the time for which the acquisition will keep running. The countdown starts as soon as the user presses the *"Start Data Acquisition"* button located in the *"Main Controls"*. The user can select the number of days, hours, minutes and seconds.

The *"File Name"* allows the user to specify a name and a path for his file. A filename must be defined to start an acquisition. If the *"Full images and measurements"* is selected, then a series of ".BMG" files with the same filename concatenated with its corresponding increment will be saved.

The *"Sample Rate"* defines the rate at which the samples are saved. When choosing the *"Measurements only"* acquisition mode, the sample rate is defined as 1/X images. To save every frame computed, enter the value "1" in the box. To keep track of only a small amount of frames, enter a higher value. When choosing the *'Full images and measurements"* acquisition mode, the sample rate is defined temporally. The fastest rate is limited to 1 per second.

Warning

Each *.BMG file can take up to 8.50 MB on the hard drive. Acquiring multiple frames can quickly sum up to multiple GigaBytes. If the total acquisition if over 1 GB, a warning message will appear. If there is only 10 GB left on the hard drive, a warning message will appear and the acquisition will be stopped.

Fast acquisition should be done on the computer's hard drive and cannot be done on an external drive or on a server hard drive since it could slow down the acquisition.

5.4. DIVERGENCE

The divergence tab opens when the divergence button is clicked in the Main Controls (refer to section **4.5.4**).

To compute the divergence and abide by the ISO-11146-1:2005 standard, the first step is to place an aberration-free lens between the 11Beamage-3 and the laser. The lens should be placed in the far-field of the laser beam while the 11Beamage-3 is at the lens' focal point. The second step is to enter the lens' focal length in the software. Since the focal length is wavelength dependent, make sure to use the correct value for your laser in the prior settings. The divergence in both main axes (x and y) are computed as defined by the ISO-11146-1:2005 and ISO-11146-2:2005 standards and displayed at the bottom of the "*Divergence*" tab (refer to annex A).

Figure 5-11 Divergence Tab

Warning

The 11Beamage-3 sensor must be placed precisely at the focal point, not at the beam waist.

5.5. RELATIVE POSITION

The "*Setup*" section, which displays the coordinate system of the 11Beamage-3 sensor on the right side, allows the user to select the parameter that will be considered as the origin position (0,0) by the software.
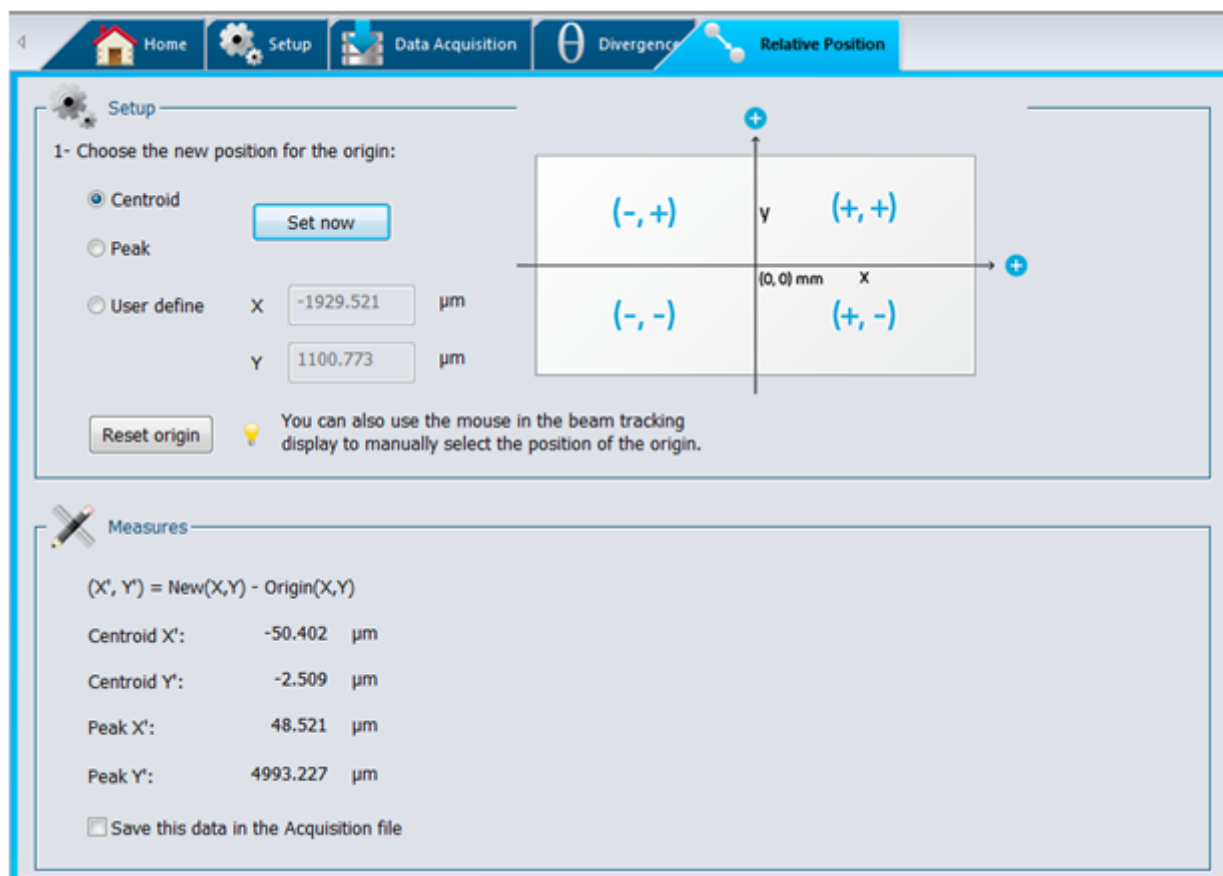
Figure 5-12 Relative Position Tab

By selecting "*Centroid*" and clicking "*Set now*", the user chooses to position the origin at the computed centroid (center of energy). By selecting "*Peak*" and clicking "*Set now*", the user chooses to position the origin at the computed energy peak (highest measured value). The option "*User define*", allows the user to manually enter origin position values for both the X and Y axes.

It is also possible to position the origin by simply clicking with the mouse in the display. This can be done in the Beam Tracking Display, which shows the coordinate system of the 11Beamage-3 sensor (refer to section 6.4). First, click on the "*Beam Tracking Display*" button at the bottom of the display screen to open

the Beam Tracking window. Then, activate the pointer button at the top of the display ![pointer button icon] ,and click where you want to position the new origin of the coordinate system. Once you have clicked on the desired point, the coordinate values for both X and Y axes will automatically be set beside "*User define*" in the "*Relative Position*" tab.
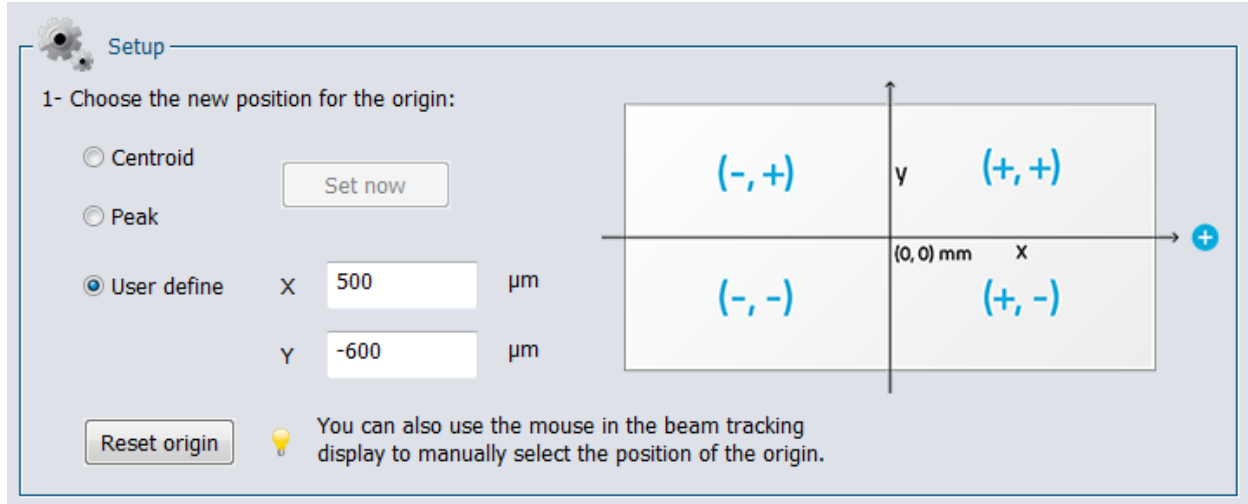
Figure 5-13 Coordinates Defined by User

To set the origin back to its default position (0,0), click on the "*Reset origin*" button below "*User define*". This will also automatically select the default option "*Centroid*" for the origin position.

Once the origin position is determined by the user, the software will calculate the difference between the coordinates of this new position and the latest computed centroid or peak coordinates. The results are displayed in the "*Measures*" section of the "*Relative Position*" tab.
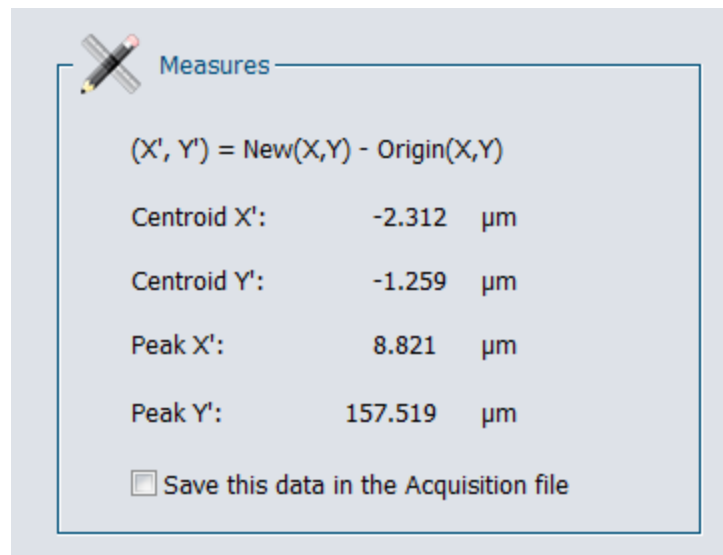
Figure 5-14 Measures Section

It is possible to save the data in the Acquisition file. To do so, select the "*Save this data in the Acquisition file*" option at the bottom of the "*Measures*" section.

5.6. CAMERA LENS

Prior to profiling a beam with a camera lens, one must adjust the Pixel Magnification Factor of the lens (see section 5.2.8).

The "*Camera lens calibration*" section allows the user to calibrate the PC-Beamage software when a camera lens is used with the 11Beamage-3. This panel is accessible by clicking "Calibrate" in the Pixel Multiplication factor section in the Setup panel or in the Show/Hide Options in the Ribbon.
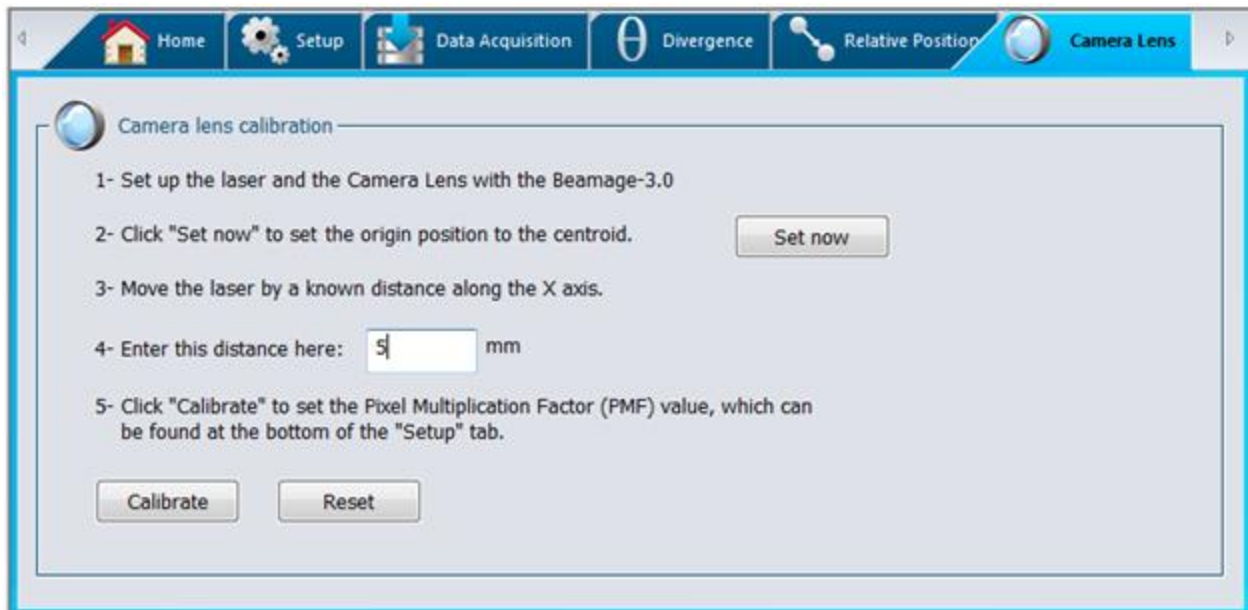
Figure 5-15 Camera Lens Calibration Section

1. Set up the laser and the camera lens with the 11Beamage-3.

2. Click on Set now to set the centroid to the current position

3. Then, move the laser source (or the 11Beamage-3 camera) by a known distance along the X axis.

4. Enter this distance (in mm) in the appropriate box and press enter.

5. Finally, click on the "Calibrate" button to automatically set the Pixel Multiplication Factor (PMF) value found in the bottom of the "*Setup*" tab. Once the PMF is set, the beam dimensions will be adjusted to compensate for the magnification of the camera lens (Beam Tracking Display).
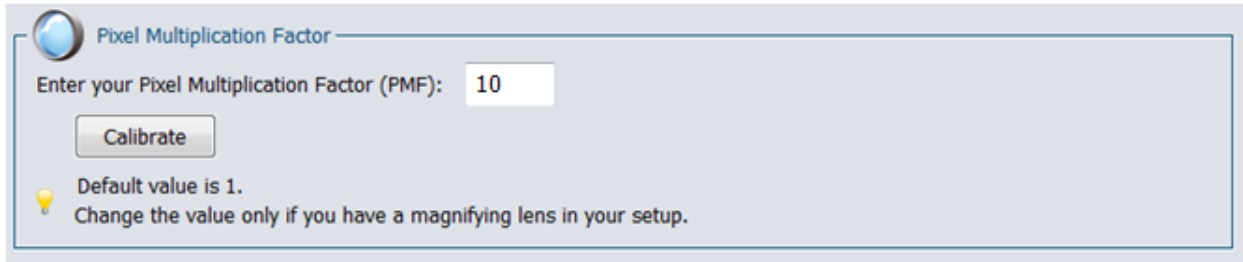
Figure 5-16 Pixel Multiplication Factor Section

6.   To return to original values for the Pixel Multiplication Factor, click on "Reset"

6.   DISPLAY PANEL

The PC-Beamage-3.0 offers four different graphical displays to view and analyze the laser beam.

3D Display: A real time display of the beam intensity in a 3D representation.

2D Display: A real time display of the beam intensity in a 2D representation.

XY Display: A real time display of the beam's XY cross-sectional graphs along the crosshairs.

Beam Tracking Display: A real time display of the beam's position stability

To choose the desired display mode, click on the corresponding icon in the lower control bar under the display panel.

Figure 6-1 Display Panel

6.1. 3D DISPLAY

The 3D Display represents the beam's intensity in three dimensions. False coloring is added to increase the contrast. The color legend used for the various intensity levels is available in the main control ribbon (refer to section 4.6.1).

Holding down the left button on the mouse while moving it, will rotate the image. The scroll button on the mouse zooms the image in or out. It is also possible to zoom in the image by pressing the "+" key on the keyboard and similarly, it is possible to zoom out the image by pressing the "-" key on the keyboard. Pressing the Ctrl button while holding down the left mouse button will pan the 3D image along its Y axis. Doing the same procedure with the Shift button pans the 3D image along its X axis.

Figure 6-2 3DDisplay

6.1.1.3D Display: Controls

The toolbar buttons on the upper right corner control the 3D image.

Print Screen: Saves a .bmp image of the current 3D display.

Reset View: Resets the display to its original parameters.

Top View: Views the 3D image from the top, creating a top-view projection.

6.2. 2D DISPLAY

The 2D Display represents the beam's intensity in two dimensions. False coloring is added to increase the contrast. The color legend used fo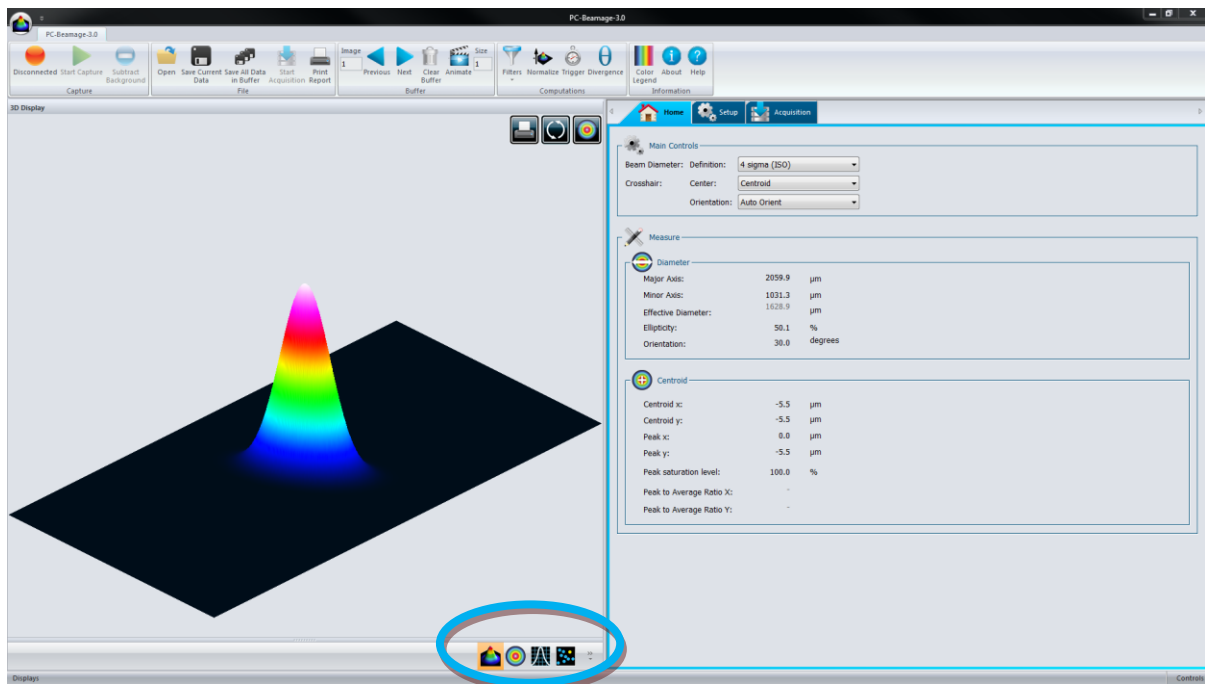r the various intensity levels is available in the main control ribbon (refer to section 4.6.1). The 2D display also features the crosshairs (set to the major and minor axis or along specified angles).
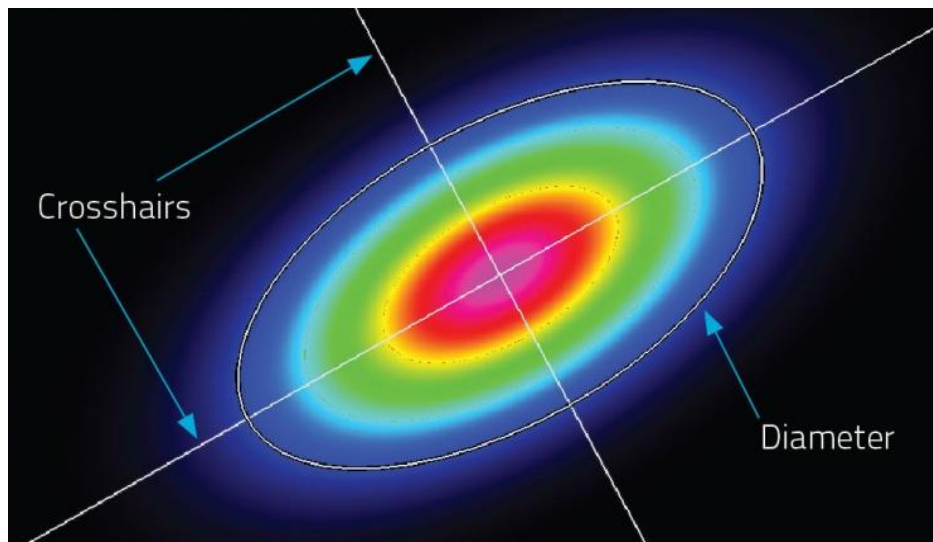
Figure 6-3 2D Display Showing Crosshairs and Diameter Positions

To optimize the software's performance, the resolution of the 2D image is downsampled when the 11Beamage-3 is streaming. Nonetheless, the computation is done on all transferred pixels. For images larger than 1000x1000 only 1/16 pixels are displayed, for images larger than 500x500 only 1/4 pixels are displayed and for smaller images all pixels are displayed. When the 11Beamage-3 is stopped or in the animate mode, all pixels are always displayed regardless of the image size.
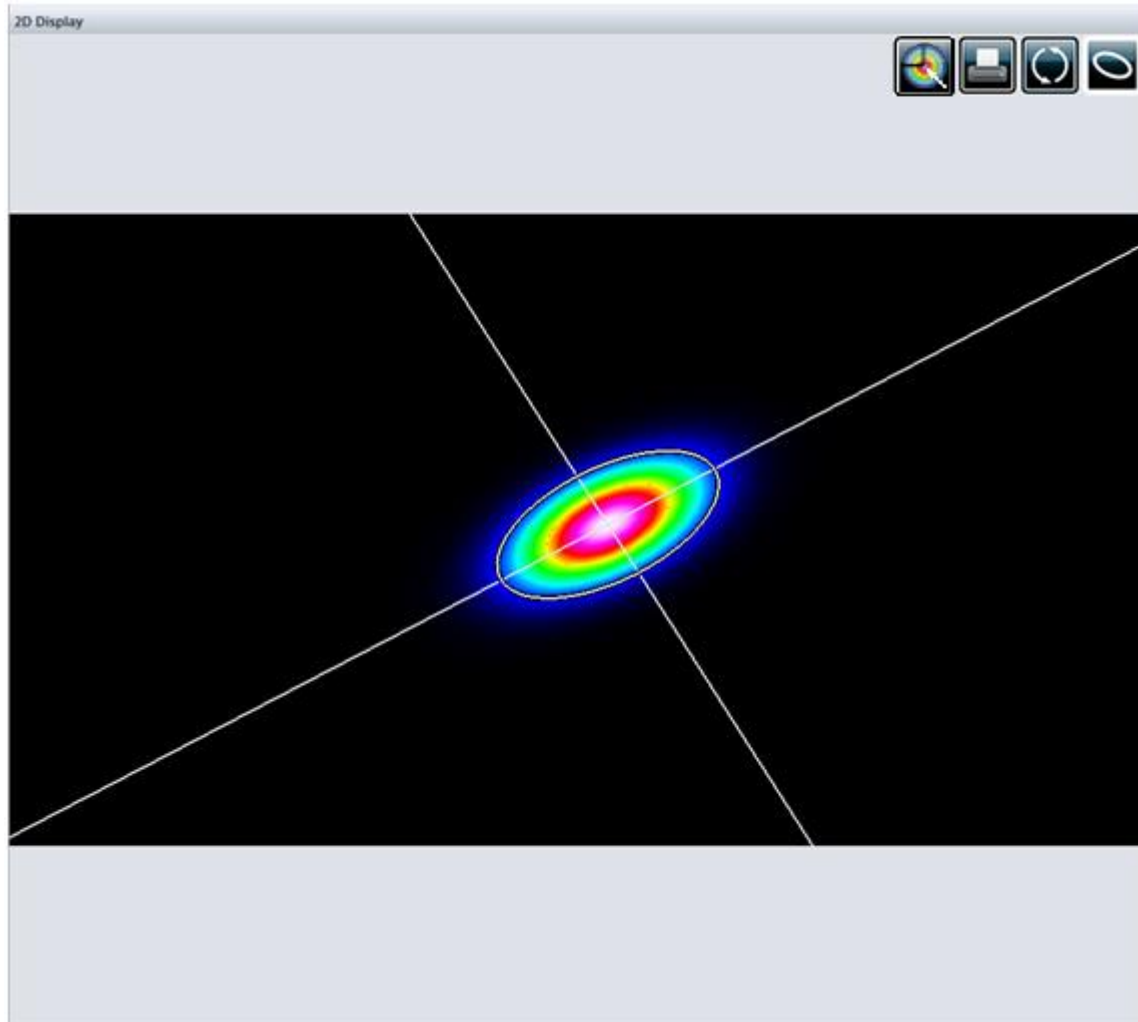
Figure 6-4 2D Display

Holding down the left button on the mouse while moving around moves the image. The "up arrow", "down arrow", "left arrow" and "right arrow" will also move the image accordingly. The scroll button on the mouse zooms the image in or out. It is also possible to zoom in the image by pressing the "+" key on the keyboard and similarly, it is possible to zoom out the image by pressing the "-" key on the keyboard.

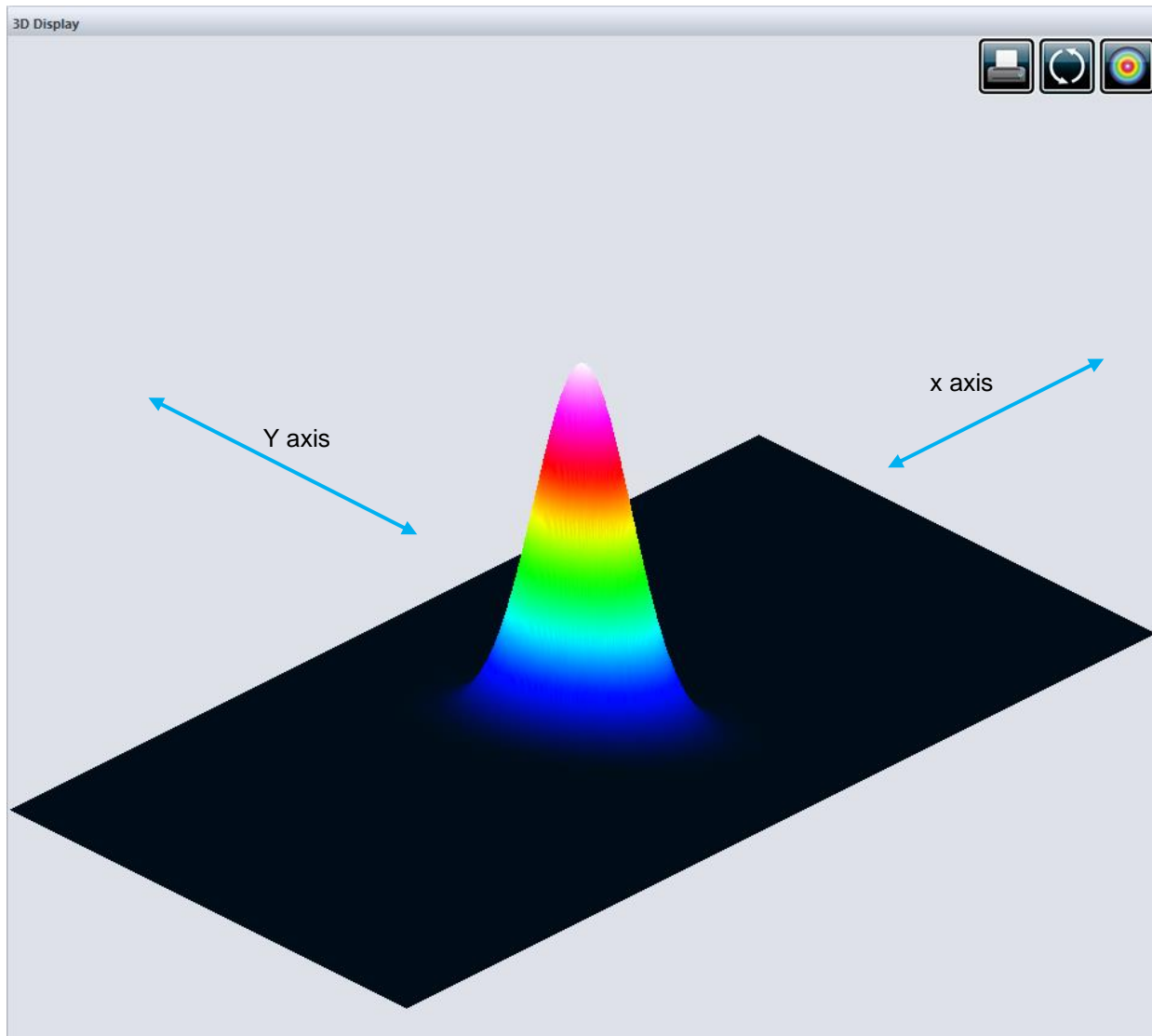### 6.2.1.2D Display: Controls

The toolbar buttons on the upper right corner control the 2D image.

Print Screen: Saves a .bmp image of the current 2D display.

Reset View: Resets the view settings to its original parameters.

Show/Hide Diameter: Displays the ellipse corresponding to the beam diameter (refer to section 5.1.1.1).

Select Active Area: Selects with cursor an active area.

6.3. XY DISPLAY

The *XY* display plots cross-sectional graphs of the beam along the crosshairs. The crosshairs position and orientation are defined in the *Home* tab (refer to section 5.1.1.2)
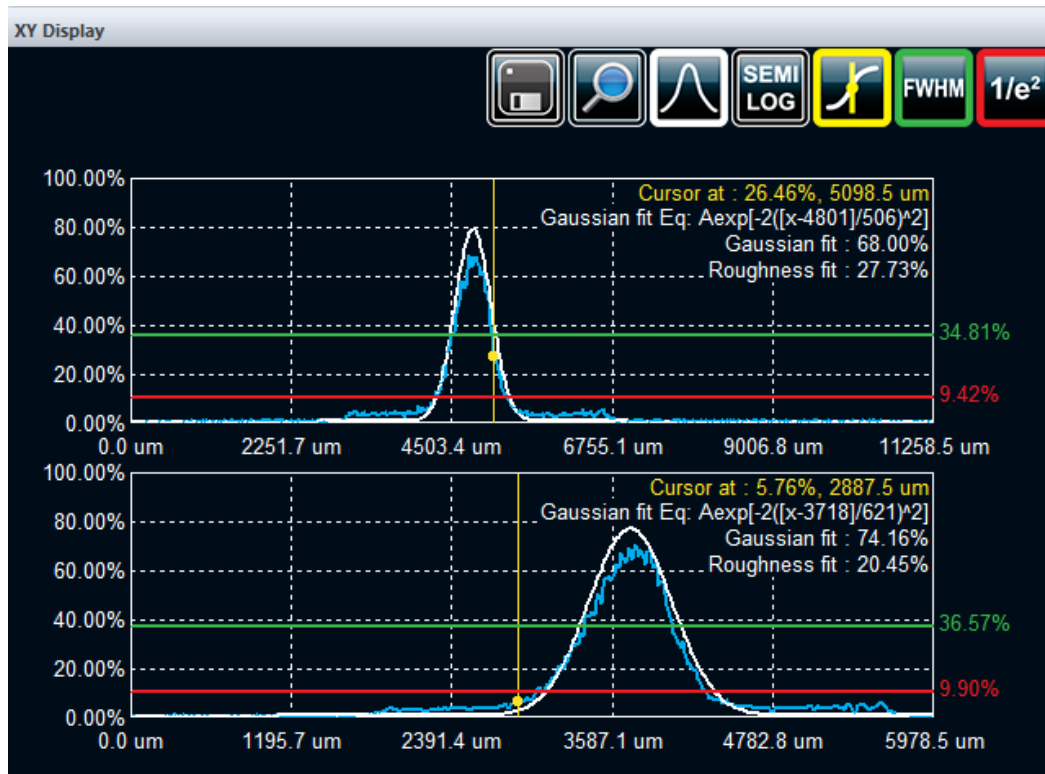
Figure 6-5 XY Display

6.3.1.XY Display: Controls

The toolbar buttons on the upper right corner control the XY graphics.

Save: Saves the crosshair information in a .TXT file. If the *"Gaussian Fit"* was activated, the equation of the curve will also be saved in the file.

Zoom: Activates the zoom for both graphics individually. Zooming can be done by selecting an area with the left mouse button. Double-clicking the image returns to the original state..

Gaussian Fit: Shows/Hides the best fitted Gaussian along the experimental curve. Refer to section 6.3.2 for more information.

Semi-Log: Transforms the linear graphics to semi-logarithmic graphs to enhance the details in the low intensity parts of the beam.

Cursor Position: Shows/Hides a cursor on each graph with their intensity and position value in the graph's upper right corner. The cursors are positioned by clicking on the desired spots with the left mouse button.

FWHM: Shows/Hides the level corresponding to the half maximum value.

1/e²   **1/e²:** Shows/Hides the level corresponding to the 1/e² value.

6.3.2. Gaussian Fit

The *"Gaussian Fit"* function fits the best Gaussian curve on the experimental data. When the "*Gaussian Fit"* is activated, it displays three information on the graphic's upper right corner.

1.   The Gaussian equation

The first information to be displayed is the equation of the fitted Gaussian. The Gaussian equation is defined by:

$$f(x) = Ae^{\left[-2\left(\frac{x-c}{w}\right)^2\right]}$$

where *w* is the beam's radius, *c* its centroid.

2.   The Gaussian Fit factor

The Gaussian Fit factor is defined as:

$$Gaussian\ fit\ (\%) = \left[1 - \frac{\sum|E_i - E_i^a|}{\sum E_i^a}\right] \times 100\%$$

where *E* is the experimental curve and E^a is the theoretical Gaussian curve.
The closer to 100%, the better the Gaussian fit.

3.   The Roughness Fit factor

The Roughness Fit factor is the maximum deviation between the theoretical Gaussian curve and the measured curve, as defined by ISO13694:2000[2]:

$$Roughness\ fit\ (\%) = \left[\frac{|E_i - E_i^a|_{max}}{E_{max}}\right] \times 100\%$$

where *E* is the experimental curve and E^a is the theoretical Gaussian curve.
The closer to 0%, the better the Gaussian fit.

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[2] International Organization for Standardization, *ISO 13694 :2000 Laser and laser-related equipment – Test methods for laser beam power (energy) density distribution, Geneva*

6.4. BEAM TRACKING DISPLAY

The Beam Tracking Display shows the variation of the position of the centroid on the sensor. The yellow dot represents the last calculated centroid position while the blue dots represent the previous ones. A dot is added to the chart at each computation. The buffer can memorize as many as 2000 calculations. The buffer is circular, which means that once it is full, it replaces the oldest value in memory by a new one. The mean position of all the centroid positions is represented by a red cross.

Figure 6-6 Beam Tracking Display

Useful ISO 11670: compliant values appear above the chart. They give an indication on how much the beam drifts from its mean position.

- *Mean*: Coordinates of the mean position of the centroid.
- *Last*: Coordinates of the last calculated position of the centroid.
- *Azimuth*: Orientation for which the drift is maximal.

- *Δ*: Overall beam positional stability
- *Δx*: Beam positional stability in the azimuth direction.
- *Δy*: Beam positional stability perpendicularly to the azimuth.
- *RMS* : RMS standard deviation value of the centroid's position (not ISO measure)

The beam positional stability values are based on the standard deviation concept[3]. Small values represent small deviations and a good stability.

Please refer to ANNEXE A (p.58) for ISO mathematical definitions of the quantities listed above.

6.4.1.Beam Tracking Display: Controls

The toolbar buttons on the upper right corner control the beam tracking plot.

Save: Saves all the centroid coordinates available in the buffer in a .TXT file.

Print Screen: Saves a .bmp image of the current beam tracking display.

Reset Buffer: Erases all the data from the buffer and clears the chart.

Zoom: Activates the zoom. Zooming can be done by selecting an area with the left mouse button and de-zooming can be done by double-clicking the image.

Set Origin Point: Sets the origin point (0, 0) of the sensor for the relative positioning, Please refer to section 4.5.4.2.

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[3] International Organization for Standardization, *ISO 11670:2003 Laser and laser-related equipment – Test methods for laser beam parameters – Beam positional Stability, Geneva*

7. TROUBLESHOOTING

7.1. WHILE TRYING TO INSTALL PC-BEAMAGE-3.0, THE FOLLOWING MESSAGE APPEARS: THE PROGRAM CAN'T START BECAUSE MSVCR100.DLL IS MISSING[..].

You must download the missing dll from Microsoft software and install it on your computer:
32 bit: http://www.microsoft.com/download/en/details.aspx?id=5555
64 bit: http://www.microsoft.com/download/en/details.aspx?id=14632

7.2. 11BEAMAGE-3 IS NOT DETECTED

- Make sure the 11Beamage-3 is connected to a USB 3.0 Super Speed port. The 11Beamage-3 will work if plugged directly in a USB 2.0 port at a slower transfer rate.

- Close the software application, disconnect and reconnect the USB 3.0 to the 11Beamage-3 and open the software application. The LED indicator on the 11Beamage-3 should blink in green and then in red before turning on green. If the LED does not turn on at the software's startup or if it does not turn on completely, please contact your Standa representative or contact us at sales@standa.LT

7.3. DO NOT DISCONNECT THE 11BEAMAGE-3 WHILE IT'S STREAMING

The 11Beamage-3 must not be disconnected when it is streaming.

7.4. THE DISPLAY AREA IS COMPLETELY WHITE

Press the "refresh" button and the display should come back.

7.5. CHANGING THE OPTICS IN FRONT OF THE 11BEAMAGE-3

Because the 11Beamage-3's sensor does not have a coverglass, it is very sensitive to dust. Change the optics in a clean environment and put the 11Beamage-3's aperture facing down to minimize the dust.

7.6. SMALL BLACK SPOTS APPEAR ON THE IMAGE

If these small black spots do not change place even if you rotate the attenuation filter, it is probably dust on the sensor. **DO NOT TOUCH** the surface of the chip to remove the dust as this will damage the sensor. **AT YOUR OWN RISK**, you can use an oil-free air jet to blow the dust away or contact your Standa representative.

7.7. IT IS NOT POSSIBLE TO START AN ACQUISITION. IT KEEPS OPENING A WARNING MESSAGE INDICATING THAT 0 GB IS AVAILABLE ON HARD DRIVE.

This is probably due to the fact the path in which the PC-Beamage-3.0 was not installed in the default C:\Program Files\GENTEC-EO\PC-Beamage-3.0 directory:

7.8. THERE IS NO SERIAL NUMBER DISPLAYED IN THE CAMERA.

Please close the PC-Beamage-3.0 software program, wait a couple of seconds and open the PC-11Beamage-3. If it does it again, please, disconnect the 11Beamage-3, connect the 11Beamage-3. If this continues, please contact your Standa representative or contact us at sales@standa.LT

7.9. THE 10 BIT ADC LEVEL IS NOT AVAILABLE EVEN WHEN THE 11BEAMAGE-3 IS CONNECTED TO A USB 3.0 PORT.

The 10 bit ADC level is only available when using a USB 3.0 port. If it is not available even when connected on a USB 3.0 port, reboot the computer. If it is still not available, please contact your Standa representative or contact us at sales@standa.LT.

8.   DECLARATION OF CONFORMITY

Application of Council Directive(s):   2004/108/EC   The EMC Directive

Type of Equipment: Laser Beam Diagnostic Equipment.
Model No.:   Beamage 3.0
Year of test & manufacture: 2012

Standard(s) to which Conformity is declared:
EN 61326 :2005/EN 61326 : 2006/ Emission generic standard

Standard	Description	Performance Criteria
CISPR 11 :2009 +A1 2010	Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement	Class A
EN 61326 :2005/EN 61326 : 2006	Limits and methods of measurement of radio interference characteristics of information technology equipment. Testing and measurements of radiated emission	Class A
IEC 61000-4-2:2001	Electromagnetic compatibility (EMC) – Part 4: Testing and measurements techniques- Section 2: Electrostatic discharge.	Class B
IEC 61000-4-3:2002	Electromagnetic compatibility (EMC) – Part 4: Testing and measurements techniques- Section 3: Radiated, Radio Frequency immunity.	Class A

We hereby declare that the equipment specified above
conforms to the above Directive(s) and Standard(s).

ANNEX A ISO11146 AND ISO11670 DEFINITIONS

The beam centroid coordinates are given by:

$$\bar{x}(z) = \frac{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} E(x,y,z)x\,dxdy}{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} E(x,y,z)\,dxdy}$$

$$\bar{y}(z) = \frac{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} E(x,y,z)y\,dxdy}{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} E(x,y,z)\,dxdy}$$

The beam widths are defined as an *"extent of a power density distribution in a cross section of beam based on the centered second order moments of the power density distribution."*

The second order moments of power density distribution are given by:

$$\sigma_x^2(z) = \frac{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} E(x,y,z)(x-\bar{x})^2\,dxdy}{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} E(x,y,z)\,dxdy}$$

$$\sigma_y^2(z) = \frac{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} E(x,y,z)(y-\bar{y})^2\,dxdy}{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} E(x,y,z)\,dxdy}$$

$$\sigma_{xy}^2(z) = \frac{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} E(x,y,z)(x-\bar{x})(y-\bar{y})\,dxdy}{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} E(x,y,z)\,dxdy}$$

The beam widths are given by:

$$d_{\sigma_x} = 2\sqrt{2}\left\{(\sigma_x^2 + \sigma_y^2) + \gamma\left[(\sigma_x^2 - \sigma_y^2)^2 + 4(\sigma_{xy}^2)^2\right]^{\frac{1}{2}}\right\}^{\frac{1}{2}}$$

$$d_{\sigma_y} = 2\sqrt{2}\left\{(\sigma_x^2 + \sigma_y^2) - \gamma\left[(\sigma_x^2 - \sigma_y^2)^2 + 4(\sigma_{xy}^2)^2\right]^{\frac{1}{2}}\right\}^{\frac{1}{2}}$$

where:

$$\gamma = \frac{\sigma_x^2 - \sigma_y^2}{\left|\sigma_x^2 - \sigma_y^2\right|}$$

The major axis is the width's maximum whereas the minor axis the width's minimum.

The effective diameter of the beam is an *"extent of a circular power density having an ellipticity greater than 0.87. [...] If the ellipticity is larger than 0.87, the beam profile may be considered to be of circular symmetry at that measuring location and the beam diameter can be obtained from:"*

$$d_\sigma = 2\sqrt{2}\left(\sigma_x^2 + \sigma_y^2\right)^{1/2}$$

The beam ellipticity is the *"ratio between the minimum and maximum widths"*

The beam orientation is the *"angle between the x-axis [...] and that or the principal axis of the power density distribution which is closer to the x-axis.".* From this definition, the angle is comprised between -45° and 45°.

$$\varphi(z) = \frac{1}{2} \arctan\left(\frac{2\sigma_{xy}^2}{\sigma_x^2 - \sigma_y^2}\right)$$

The beam's divergences transformed by an aberration-free focusing element of focal length *f* are given by the following equations:

$$\theta_x = \frac{d_{\sigma x}}{f}$$

$$\theta_y = \frac{d_{\sigma y}}{f}$$

$$\theta_\sigma = \frac{d_\sigma}{f}$$

In the laboratory or usual system of coordinates (X',Y',Z'), the coordinates of the latest calculated position of the centroid for both X' and Y' axes are given by the following equations:

$$\bar{x}'(z) = \frac{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} E(x',y',z')x'dx'dy'}{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} E(x',y',z')dx'dy'}$$

$$\bar{y}'(z) = \frac{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} E(x',y',z')y'dx'dy'}{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} E(x',y',z')dx'dy'}$$

The coordinates of the mean position of all computed centroids for both X' and Y' axes are thus defined by the following equations, which are simple arithmetic means,

$$\bar{x}'_M = \frac{\sum_i \bar{x}'_i}{n}$$

$$\bar{y}'_M = \frac{\sum_i \bar{y}'_i}{n}$$

Where $\bar{x}'_i(z)$ and $\bar{y}'_i(z)$ are the centroids coordinates for X' and Y' axes already saved in the buffer, and *n* the number of computed centroid positions saved in the buffer.

The azimuth angle, which is the angle between the usual X' axis and all computed centroids, is given by the following equation:

$$\psi = \frac{1}{2} \arctan\left(\frac{2s_{xy}^2}{s_x^2 - s_y^2}\right)$$

Where we have the following definitions:

$$s_x = \sqrt{\frac{\Sigma_i \bar{x}_i^{\;2}}{n-1}}$$

$$s_y^{\;2} = \frac{\Sigma_i (\bar{y}_i' - \bar{y}_M')^2}{n-1}$$

$$s_{xy}^{\;2} = \frac{\Sigma_i (\bar{x}_i' - \bar{x}_M')(\bar{y}_i' - \bar{y}_M')}{n-1}$$

In the beam axis coordinate system (X,Y,Z), the beam positional stability values in the azimuth direction (X) and perpendicularly to the azimuth direction (Y), which are 4 times the standard deviations of all computed centroid values, are given by the following equations:

$$\Delta_x(z) = 4s_x$$

$$\Delta_y(z) = 4s_x$$

The overall positional stability is given by:

$$\Delta(z) = 2\sqrt{2}s$$

In the previous 3 equations, the standard deviations are defined by the following equations:

$$s_x = \sqrt{\frac{\Sigma_i \bar{x}_i^{\;2}}{n-1}}$$

$$s_y = \sqrt{\frac{\Sigma_i \bar{y}_i^{\;2}}{n-1}}$$

$$s = \sqrt{\frac{\Sigma_i \bar{x}_i^{\;2} + \bar{y}_i^{\;2}}{n-1}}$$

$\bar{x}_i^{\;2}$ and $\bar{y}_i^{\;2}$ are derived from $\bar{x}_i'^{\;2}$ and $\bar{y}_i'^{\;2}$ by transformation of coordinates. (X',Y',Z') is the usual or laboratory coordinate system and (X,Y,Z) is the beam axis coordinate system.

The RMS standard deviation value of the centroid position, which is not an ISO standard, is given by the following equation:

$$RMS = \sqrt{\left(\frac{\Sigma_i x_r^2 + y_r^2}{n}\right)}$$

Where $x_r^2 \; and \; y_r^2$ are relative values.

ANNEX B 11BEAMAGE-3 DRIVER INSTALLATION QUICK GUIDE

1) Do not connect the *11Beamage-3*'s USB cable to your computer before installing the appropriate software and drivers. The camera will not be recognized if so.

2) The latest available version of *PC-Beamage-3.0* must be installed before setting the drivers. It can be downloaded from our web-site.

3) If the software is already installed on your computer, please make sure it is the latest available version of *PC-Beamage-3.0*. To do so, open the *PC-Beamage-3.0* software and click on *About*. Another window will appear and you will be able to *Update* the software.
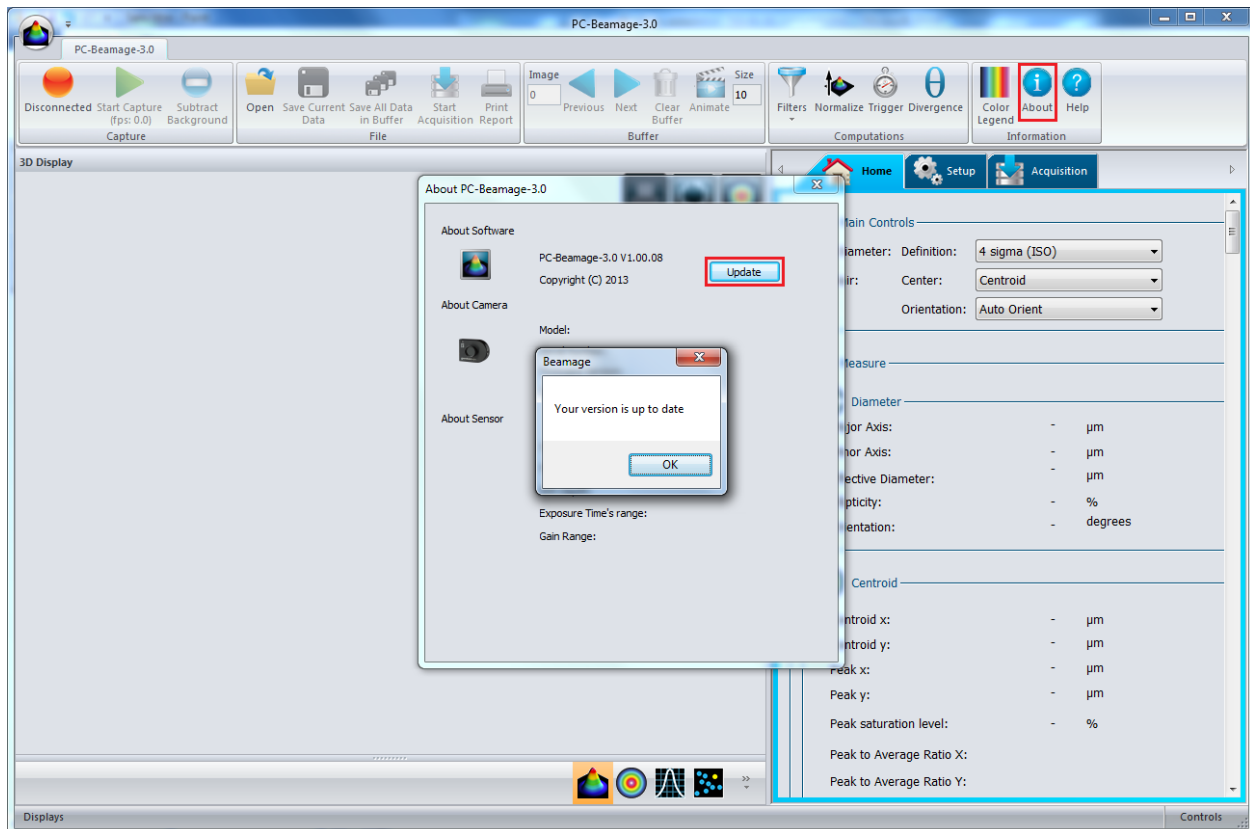
Figure B- 1: PC-Beamage-3.0

4) You can now open the *Drivers Installer*. The latest version can be downloaded from our web-site. Once the file is opened, a security warning should appear. Click on *Run.*
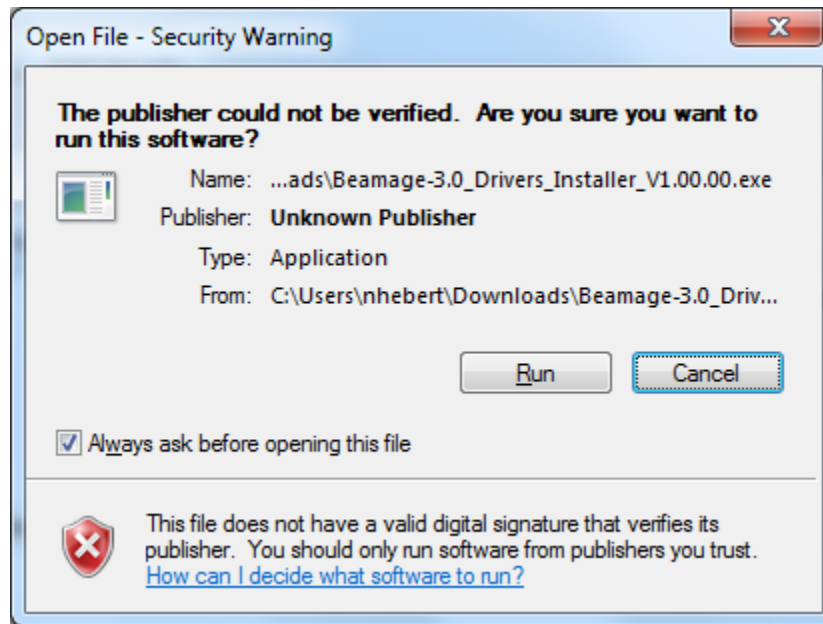
Figure B- 2: Security Warning

5) Choose the option that corresponds to your operating system. Please note that Windows XP is not officially supported and thus Standa does not provide assistance if this OS is used.
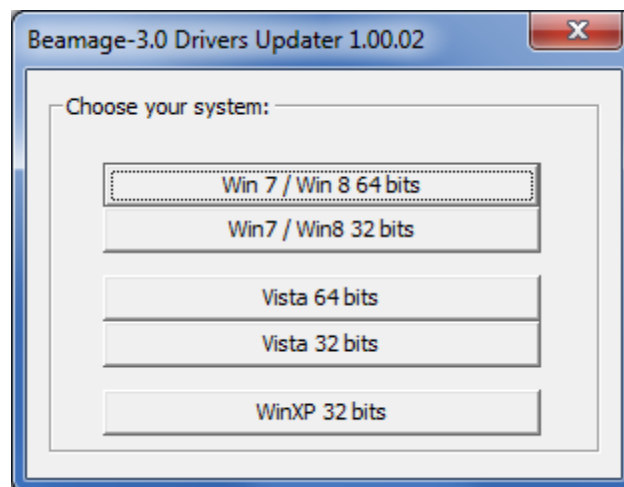
Figure B- 3: Choose your system

To find out what is your operating system, click on the *Start* (Windows home screen) button and type in *System* in the search field. Click on *System* under *Control Panel*. A window will appear, indicating which operating system is used. The x64 choices are applicable to 64-bit systems while the x86 choices are applicable to 32-bit systems.
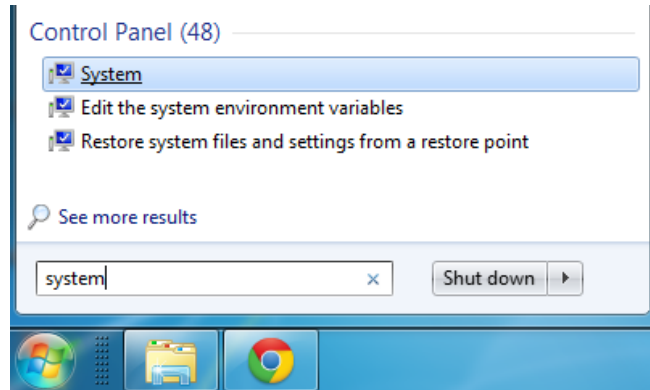
Figure B- 4: Search for "System"
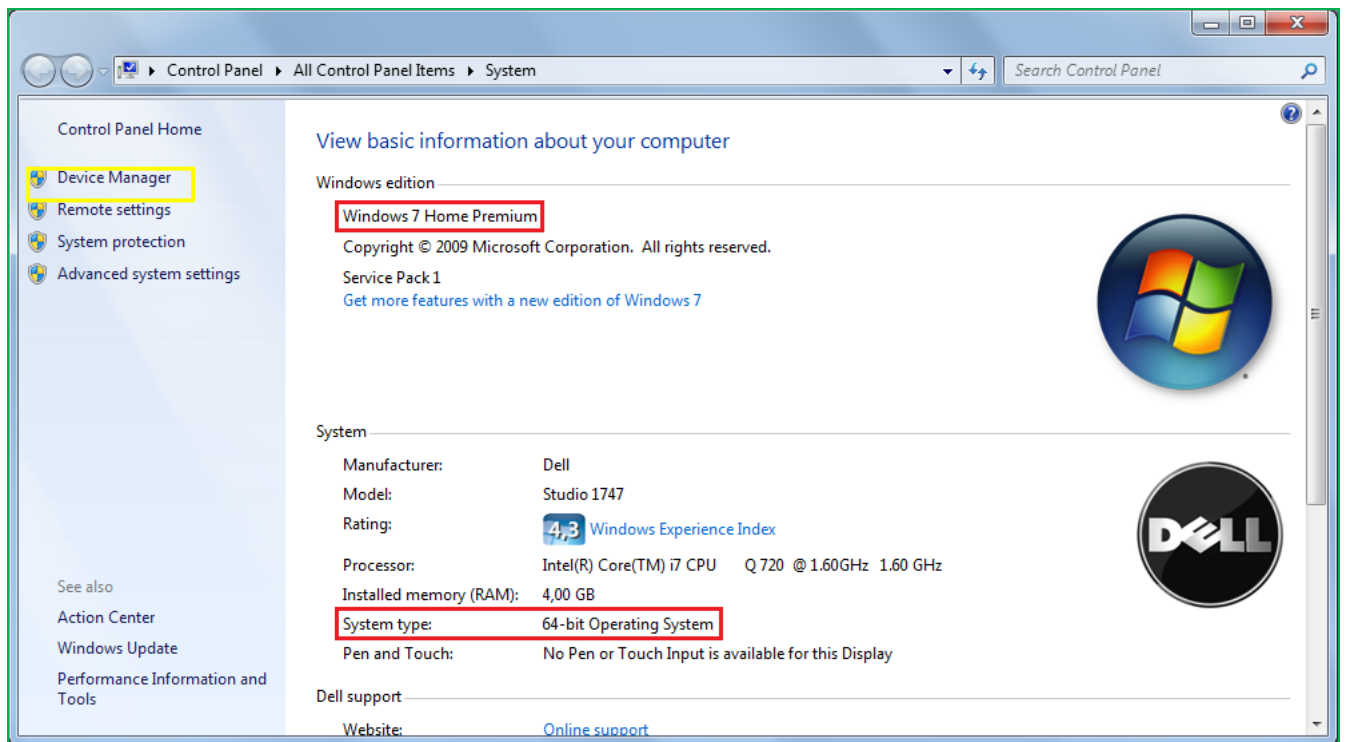
Figure B- 5: System information

6) After choosing the operating system, you will be asked to unplug the camera. If you followed the former steps, the camera should already be unplugged. Click on *OK*.
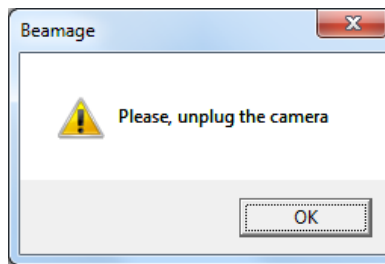
Figure B- 6: Unplug the camera

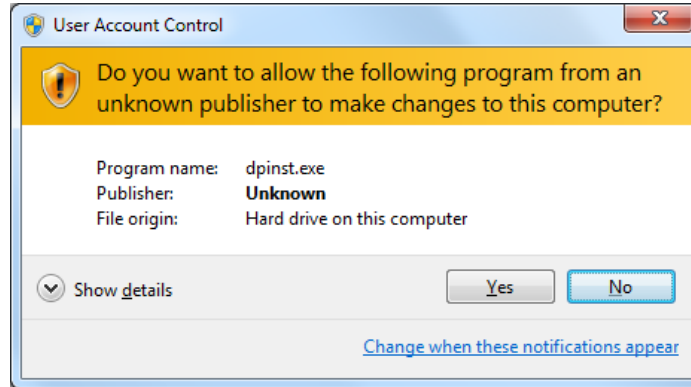7) You will be asked if you want to allow the program to make changes to your computer. Click on *Yes*.

Figure B- 7: User Account Control
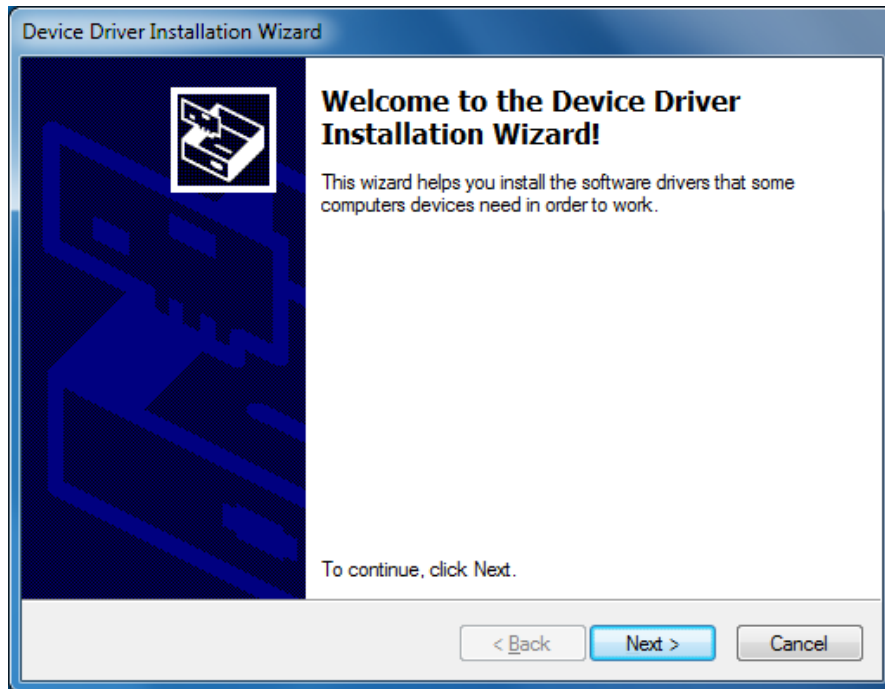
8) The driver installation wizard will appear. Click on *Next*.

Figure B- 8: Device Driver Installation Wizard

9) To confirm that you want to install the device software, click on *Install*.
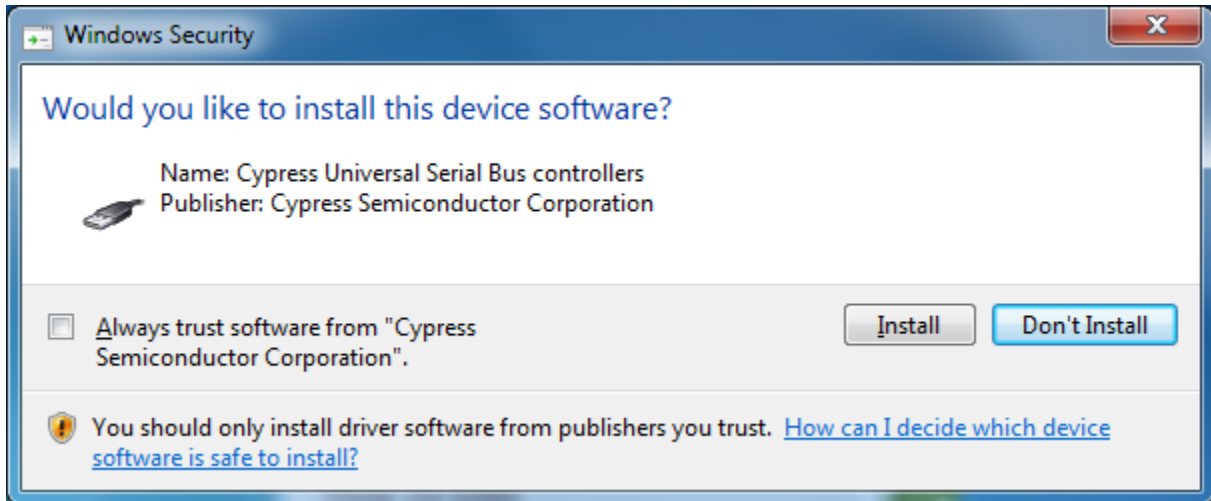
Figure B- 9: Confirmation Window
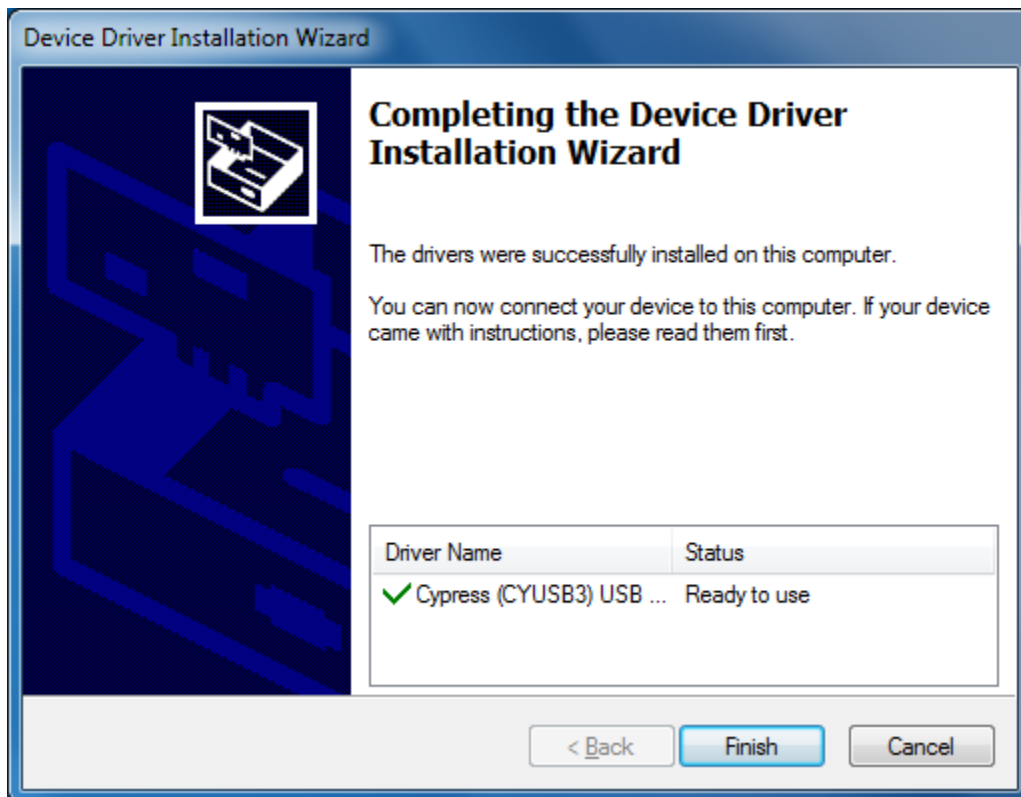
10) Once the installation is completed, click on *Finish*.

Figure B- 10: Installation Completed

11) You will be prompted to connect the camera. Connect it through your USB port, but **DO NOT CLICK ON** *OK* **RIGHT AWAY**. Wait for the following message to appear at the bottom right of your screen before clicking on *OK*.
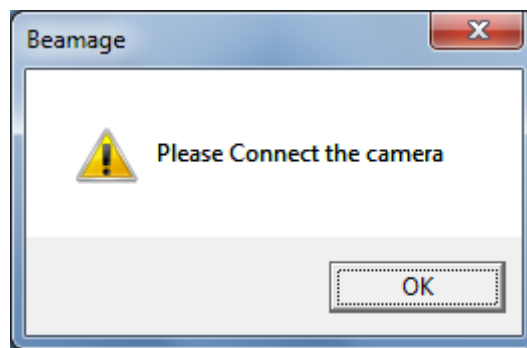

Figure B- 11: Driver installed successfully (1)

Figure B- 12: Connect the camera

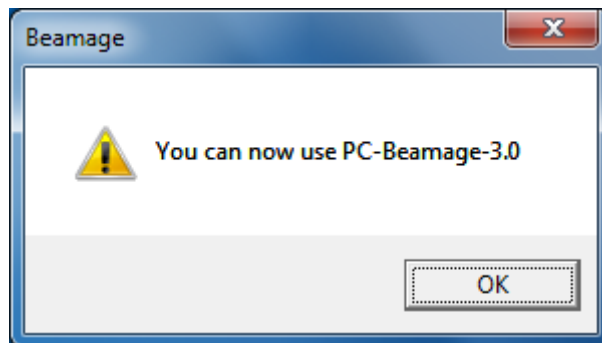12) Another window will inform you that you can now use PC-Beamage-3.0. Click on *OK*.

Figure B- 13: You can now use PC-Beamage-3.0

13) To allow the device to be recognized by your computer, unplug and plug back the USB cable.

14) Start the PC-Beamage-3.0 application. A camera selector will appear, with a series of zero as the single option. Meanwhile, the last driver will be installed. Wait for the following message to appear at the bottom right of your screen. Click on *OK* in and close the application.
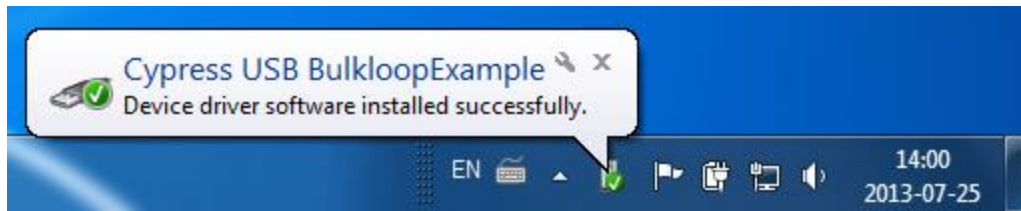

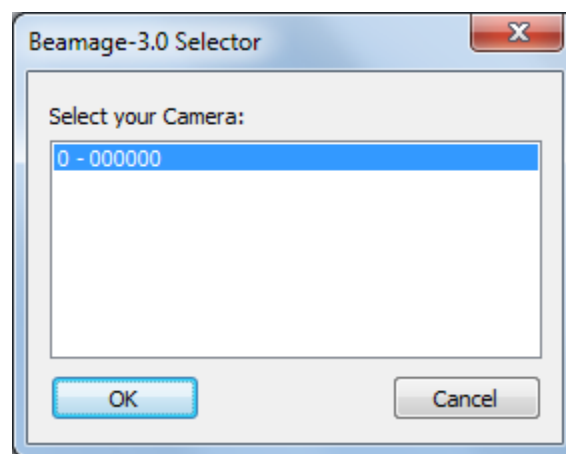Figure B- 14: Driver installed successfully (2)

Figure B- 15: Camera Selector (1)

15) Restart the PC-Beamage-3.0 application. Select your camera and click on *OK*. The 6 digits following the dash correspond to the serial number of your device. You are now ready to use your 11Beamage-3.
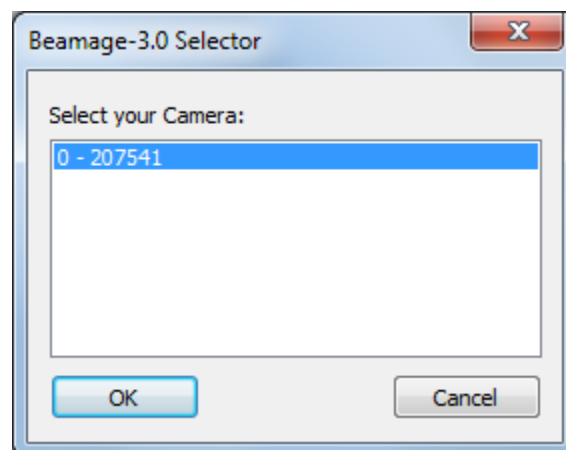

Figure B- 16: Camera Selector (2)

Verify that the driver has been correctly installed

It is not necessary to follow these steps to install the USB drivers. They are verification steps only.

1) Open your Device Manager. To open the *Device Manager*, click on the *Start* (Windows home screen) and type in *Device Manager* in the search field. Click on *Device Manager* under *Control Panel*. Be careful not to click on *Devices and Printers* instead of *Device Manager*.
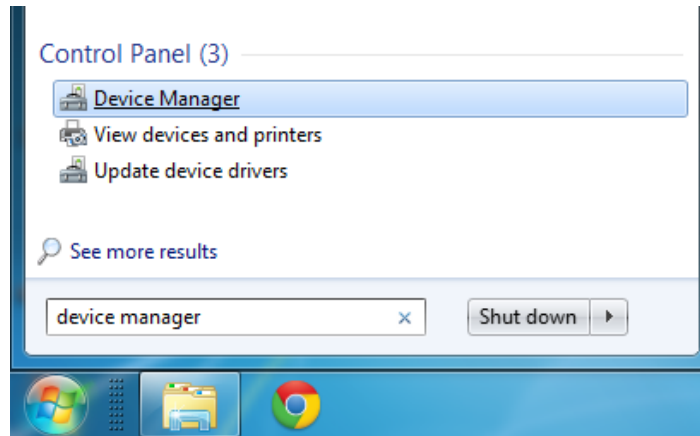
Figure B- 17: Search for "Device Manager"

You can also open the Device Manager through the System Window (refer to the yellow rectangle in **Error! Reference source not foundError! Reference source not found.**)

2) Close the PC-Beamage-3.0 application (if it is already opened). Connect the 11Beamage-3 camera to your computer. If everything went well until now, the device *Cypress USB BootLoader* should be marked by a yellow warning in the *Device Manager*. It should be located under *Universal Serial Bus controllers*.
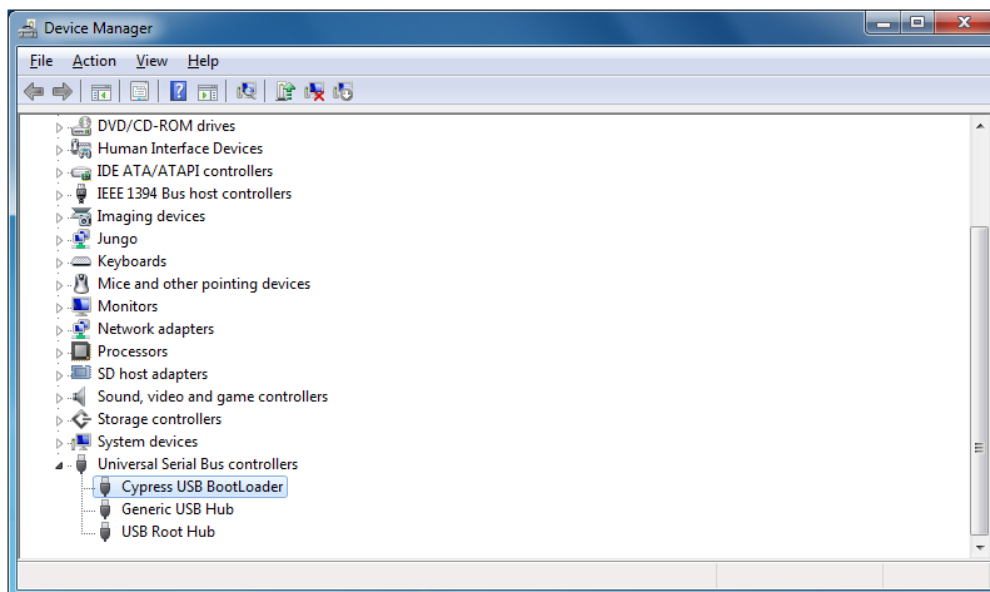
Figure B- 18: Cypress USB BootLoader

3) Open PC-Beamage-3.0 and make sure *Cypress USB BootLoader* has been replaced by *Cypress USB BulkloopExample.*
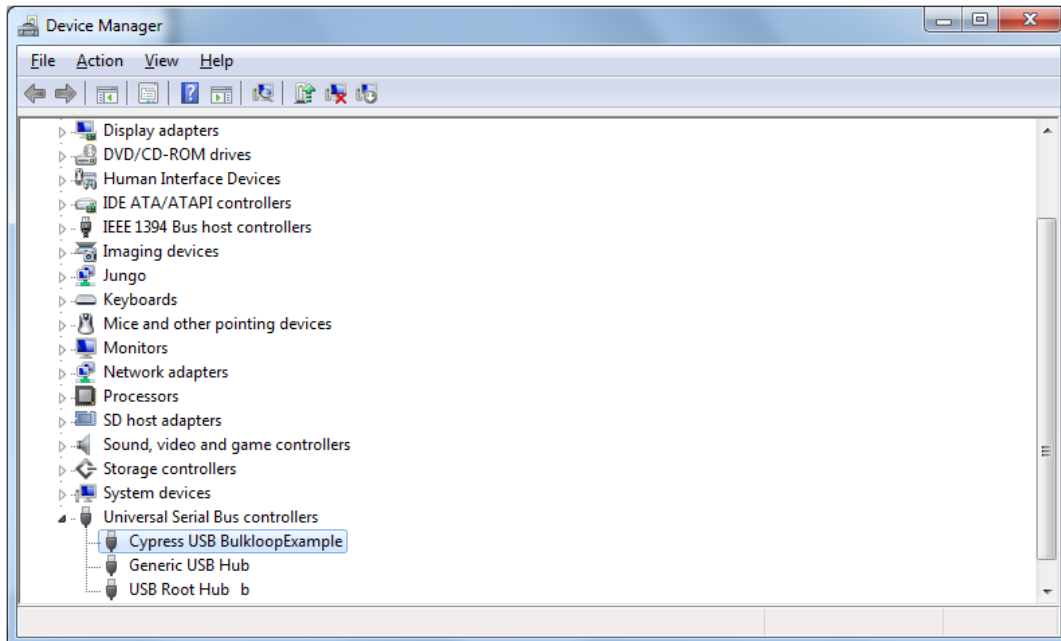

Figure B- 19: Cypress USB BulkloopExample

ANNEX C 11BEAMAGE-3 FIRMWARE INSTALLATION QUICK GUIDE

1) If the software version of the PC-Beamage-3.0 is not compatible with the 11Beamage-3's firmware version, an error message will appear. ***If so, it is important to update the firmware version and to reinstall the drivers in order to use the PC-Beamage-3.0's new functions***.

2) First, download the latest BeamageUpdater available on Standa's website.

3) Connect the 11Beamage-3 to your computer. If the 11Beamage-3 is already connected, please disconnect and reconnect it.

4) Run the CameraUpdater.

5) Click on "Update".

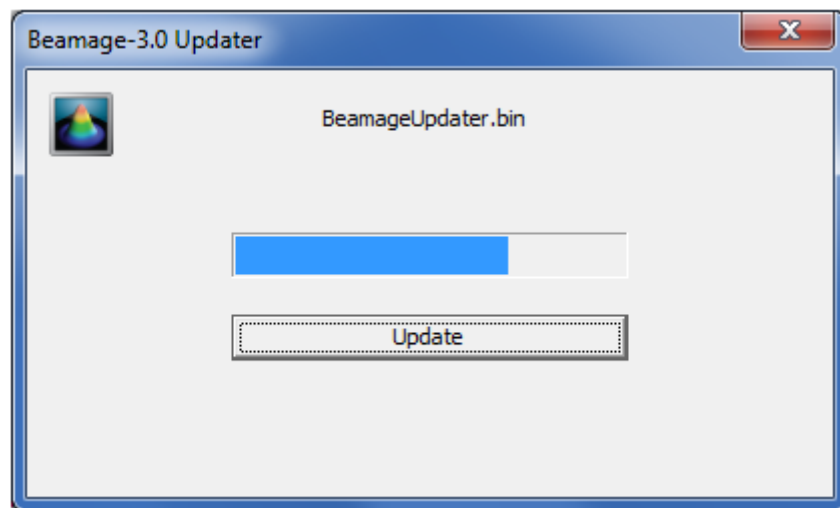Figure C-1

6) The 11Beamage-3 Updater might ask you to reset the 11Beamage-3. If so, please disconnect and reconnect the 11Beamage-3 and click on "Update" again.

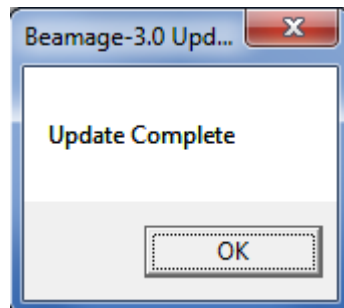7) Once this is done, a message box will appear. Click on *OK*.

Figure C-2

8) Once the Bemage-3.0's firmware is up to date, update the drivers by following the steps described in Annex B. Please note that even if the drivers were previously installed, the new software and firmware versions need a new driver installation.

ANNEX D RECYCLING AND SEPARATION PROCEDURE FOR WEEE

This section is used by the recycling center when the 11Beamage-3 reaches its end of line. Breaking the calibration seal or opening the 11Beamage-3's case will void the warranty

The compete 11Beamage-3 contains:

1 11Beamage-3

1 USB 3.0 cable with screw locks

1 BNC to SMA connector

1 Software CD-ROM

1. Separation

Plastic: Aperture cap, SMA cap.

Metal: 11Beamage-3's case, screws, SMA connector, BNC to SMA connector, ND filter holder.

Wires: USB cable.

Printed circuit board: inside the 11Beamage-3.

Glass: ND filter.

CD: CD-ROM.

2. Dismantling procedure

Remove the 3 screws on the BEAMAGE's back cover with an Allen key.

Remove the 1 screw holding the PCB's with a flat screw driver.

Cut the wire between the PCB and the SMA connector.

Remove the ND filter and remove the glass with a spanner wrench.