BEAMAGE 3.0

CMOS Beam Profiling Camera

KEY FEATURES

1. **USB 3.0 for the Fastest Transfer Rates**
   Up to 10X faster than regular USB 2.0 connections (also USB 2.0 compatible)
2. **High Resolution**
   2.2 MPixels resolution gives accurate profile measurements on very small beams
3. **Large Area Sensor**
   The 11.3 x 6.0 mm sensor allows to measure very large beams
4. **ISO Compliant**
   D4σ Definition of Diameter, Centroid, Ellipticity and Orientation are ISO 11146:2004 and 11146:2005 compliant
5. **Intuitive Software Interface**
   Easy to navigate interface, with many display and control features:
   - 2D, 3D and XY Displays
   - Background Subtraction Function
   - Unique "Animate" Function
   - Gaussian Fit
   - Semi-Log Graph
6. **External Trigger**
   To synchronize the camera with a pulsed laser
7. **Low-Cost**
   The most affordable, large size camera-based beam profiler on the market

AVAILABLE MODEL

Beamage 3.0
(⅔ in CMOS Camera)

MAIN FUNCTIONS

Subtract Background | Animate | Normalize | Filter | Trigger | Active Area (ROI) | Image Averaging | Pixel Addressing

ACCESSORIES

Stand with Delrin Post
(Model Number: 200428)

CUB, CUB-UV & EAM-2
Beam Splitters and Attenuators

Stackable ND Filters
(0.5, 1.0, 2.0, 3.0 & 4.0)

UV Converters &
IR Adaptors

Pelican Carrying Case

SEE ALSO

ACCESSORIES FOR BEAM DIAGNOSTICS 186
LIST OF ALL ACCESSORIES 188

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SPECIFICATIONS

MODELS	BEAMAGE 3.0
SENSOR TECHNOLOGY	CMOS
EFFECTIVE APERTURE	11.3 x 6.0 mm

MEASUREMENT CAPABILITY	
Wavelength Range	350 - 1150 nm
Pixel Count	2.2 MPixels
H x V	2048 x 1088
Pixel Dimension	5.5 x 5.5 µm
Minimum Measurable Beam	~55 µm
Shutter Type	Global
Frame Rate (at 1 MPixels)	10 fps
RMS Noise	1000:1 (60 dB)
ADC Level (User Setable)	12 bit (default) / 10 bit (option)
DAMAGE THRESHOLDS [a]	
Maximum Average Power	1 W
Saturation Level (1064 nm)	CW: 10 W/cm^2 ; Pulsed: 300 µJ/cm^2
SOFTWARE	
Displays	2D, 3D and XY
Display Features	2D: Print Screen, Reset View, Show/Hide Beam Diameter
	3D: Print Screen, Reset View, Top View
	XY: Save Data, Zoom, Gaussian Fit, Semi-Log, Show/Hide Cursor, Show/Hide FWHM, Show/Hide 1/e^2
Beam Diameter Definitions	D4σ (ISO compliant)
	1/e^2 along crosshairs (13.5%)
	FWHM along crosshairs (50%)
	86% effective diameter (D86)
Buffer Controls	**Open File, Save Current Data, Save All Data, Previous/Next Image, Clear Buffer, Animate**
Printing and Reports	**Full Report in Print Ready Format (2D, 3D, XY, Measures, Parameters)**
	Print Screen in BMP format (2D and 3D)
PHYSICAL CHARACTERISTICS	
Sensor Size	11.3 x 6.0 mm
Sensor Area	0.67 cm^2
Dimensions (not including filter)	61H x 81.1W x 19.7D mm
Weight (head only)	139 g
ORDERING INFORMATION	
Full Product Name	BEAMAGE 3.0
Product Number (Stand not included)	201939 [b]

a. With ND4 filter.
b. Available for order now, deliveries start in April 2013. Ask your Gentec-EO representative for pricing.

Specifications are subject to change without notice

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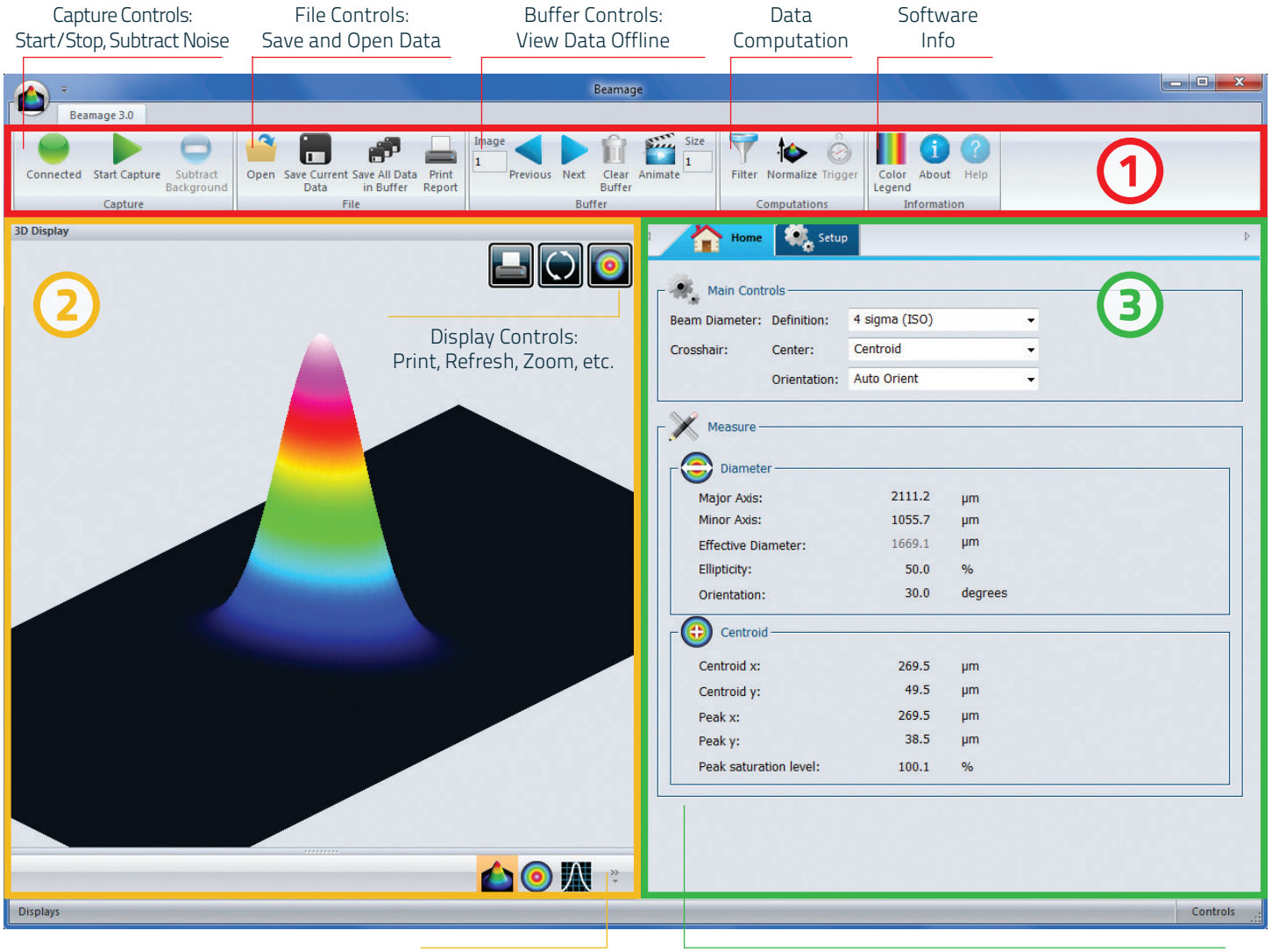
INTUITIVE SOFTWARE INTERFACE



1 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 computations such as a very useful spatial filter and a normalizing function.

2 DISPLAYS

The left-hand side of the software is the display panel. 3 displays are available: 3D, 2D and XY (cross-sectional graphs along the crosshairs). The various displays are chosen using the corresponding icons at the bottom of the panel. Convenient Print Screen controls are located the 2D and 3D displays and allow the user to save an image of the current view in BMP format.

3 HOME and SETUP TABS

The right-hand side of the software contains the Home and Setup tabs. The Home tab allows the user to select the type of measurements performed (like 4-sigma and FWHM). It also shows the resulting measures of the beam. The Setup tab contains all the measurement parameters, like Exposure Time, Image Orientation, Averaging, Active Area definition (ROI) and more.

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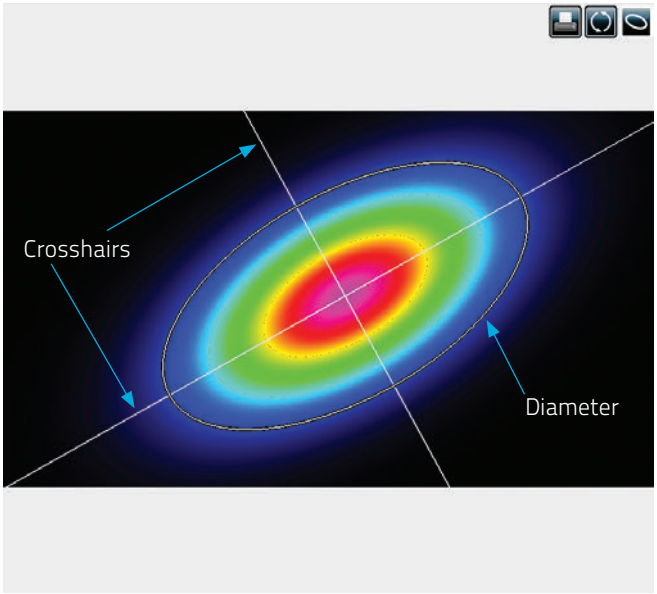
2D, 3D AND XY DISPLAYS



2D DISPLAY

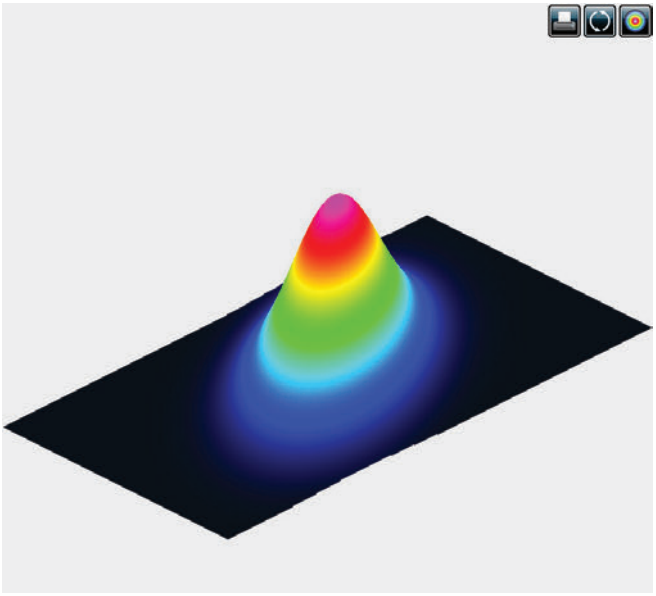
The 2D display features the crosshairs (set to the major and minor axis or along specified angles) and the measured diameter of the beam. This diameter varies with the chosen definition (4-sigma, FWHM, $1/e^2$, etc.) and its display can be turned ON or OFF. The Print Screen button allows to save a picture of the current screen in BMP format.

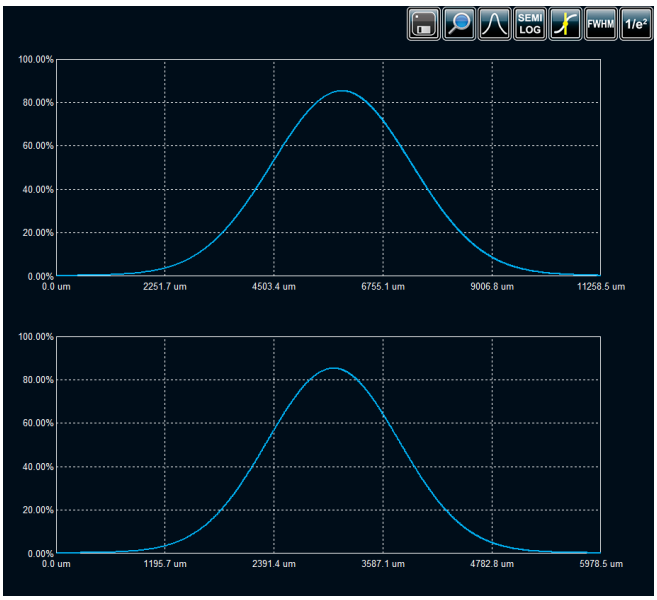
Print Screen Reset View Show/Hide Diameter

3D DISPLAY

The 3D display shows the actual shape of the beam. It is possible to easily zoom, pan and rotate the data. The very useful Reset button allows to put the data back in its original configuration. This display also features a Print Screen button to save the latest image in BMP format.

Print Screen Reset View Top View





XY DISPLAY

The XY display plots cross-sectional graphs of the beam along the crosshairs. This display features many useful tools, like zoom, cursor, and FWHM and $1/e^2$ level bars. It is also possible to display the graphs in semi-log format to enhance the details in the low intensity parts of the beam.

Save Data Zoom Gaussian Fit
Semi-Log Graph Show/Hide Cursor Show/Hide FWHM

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MAIN FUNCTIONS

SUBTRACT BACKGROUND

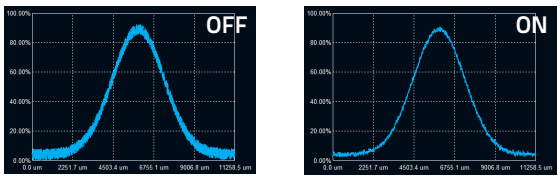
The background subtraction function is a necessary tool to have an accurate measurement and to abide by the ISO-11146-3:2004 standards. By taking 10 images and averaging them pixel by pixel to compute the average background map, contamination of all images can be avoided with the help of environment noise subtraction.

ANIMATE

Give life to your measures with the animate function. With as much as 32 frame images temporarily saved in the buffer, simply pressing the animation button will create a movie with any display (2D, 3D and XY). This allows to visualize the beam while working offline and have a recalculation process if the beam diameter definition or crosshair parameters are changed.

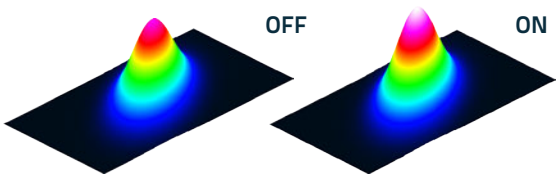
FILTER

Filter out the noise in your beam profile by using this spatial filter function. This tool is great for low quality lasers or low level signals.



NORMALIZE

The normalize function spreads the intensity over the full range (0% to 100%). This is especially useful with low level signals or to enhance the variations in the beam.



TRIGGER

For the case of pulsed laser sources, the trigger function will be useful to synchronize the system's capture rate with the source's repetition rate, especially when this one is low (<16 Hz). To be achieved, a TTL (0-5 V) or other (1.1-24 V) trigger signal can be connected to the Beamage 3.0 camera via a BNC or SMA plug.

IMAGE AVERAGING

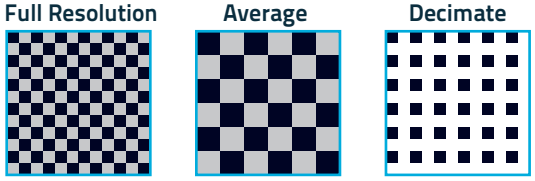
The image averaging function uses a temporal filter to provide the possibility to take 2, 5 or as much as 10 images of the beam to create a single time-averaged image with them. This process will smooth the beam fluctuations that can occur over time when working with unstable laser sources.

ACTIVE AREA (ROI)

Increase the data transfer rate by reducing the area of the sensor that is scanned. This tool is perfect for small beams that don't need the full sensor area.

PIXEL ADDRESSING

Increase the data tranfer rate by using larger pixels or by reducing the number of pixels. This is great for large beams that don't need the full resolution.



Every function may not be available yet

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CHOOSING THE CORRECT BEAM DIAMETER DEFINITION

Since Gaussians are infinitely large, borders have to be defined for the validity of calculation. To suit all types of requirements, the Beamage 3.0 software offers 4 different definitions for the beam diameter (d_σ) measurement. The first 3 definitions are appropriated for elliptical and circular profiles and the last one is for circular profiles only:

- **4 sigma (ISO):** The beam diameter definition is set by default to 4 sigma because it conforms to the ISO 11146-1:2005[1] and ISO 11146-2:2005[2] standards. With this definition, the computation time is raised and thus the frame rate is reduced because almost the entire image (4 times the curve standard deviation) is used to compute the beam parameters.
- **1/e2 along crosshairs (13.5%):** This definition is similar to 4 sigma but allows a faster frame rate. With this definition, the Gaussians are cut where the energy or intensity reaches 13,5 % of the peak value. Users can use this definition to increase the frame rate and still have a good approximation of the diameter of their elliptical beam.
- **FWHM along crosshairs (50%):** This definition is also faster than 4 sigma and works in a similar fashion as 1/e2 along crosshairs, but clips the beam at 50% of the peak value.
- **86% effective diameter (D86):** This beam definition is designed for circular (or almost circular) profiles only. It computes the diameter of a circular beam containing 86% of the total energy or intensity. Since the software assumes the beam is cicular, it does not calculate the major and minor axes, nor the orientation and ellipticity, which makes D86 the fastest measurement mode.

BEAM CENTROID, ELLIPTICITY AND ORIENTATION (ISO 11146:2005[1,2] COMPLIANCE)

The **beam centroid** (center of energy) coordinates for both X and Y axes are given by these equations, which are weighted means for energy:

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

The **ellipticity**, which can take a value between 0% and 100%, is defined as the ratio between the shorter (minor axis) and longer (major axis) widths. Evidently, a perfectly circular beam will have an ellipticity of 100%.
The **beam orientation**, which can take a value from -45° to 45°, is defined as the angle between the X axis of the sensor and the beam axis (either minor or major, whichever is closest) .

GAUSSIAN FIT AND ROUGHNESS FIT

According to the ISO 13694:2000[3] standards , the roughness fit factor, which is an indicator of the maximum deviation between the theoretical Gaussian curve and the measured one, takes a value between 0% and 100% and is given by this equation:

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

E is the measured curve and E^a the theoretical one. The closer to 0% the better is the roughness fit.

The Gaussian fit factor, on the other hand, indicates how the experimental curve is close to a theoretical Gaussian. It can take a value between 0% and 100% and is given by this equation:

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

E is the measured curve and E^a the theoretical one. The closer to 100% the better is the Gaussian fit.

1. ISO 11146-1:2005 : methods for measuring beam width, among others, only applicable for stigmatic and simple astigmatic beams.
2. ISO 11146-2:2005 : applicable to general astigmatic beams or unknown types of beams. Within this standard, the description of laser beams is done with the second order moments of the Wigner distribution. Relevant physical quantities such as beam widths can be calculated from them.
3. ISO 13694:2000 : test methods for laser beam power (energy) density distribution.

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