BEAM DIAGNOSTICS – BEAMAGE-3.0 SERIES

TECHNICAL NOTE

PROFILING IR LASERS: SHOULD I USE AN IR ADAPTOR OR A BEAMAGE-3.0-IR?

This technical note is intended for users who are working with NIR lasers and are looking for easy-to-use and complete beam profiling solution. Since we offer two options for NIR applications (the *Beamage-3.0-IR* beam profiling camera and *the IR Adaptor* accessory for *Beamage-3.0*), we are supplying this document to list the differences between both of these options and to give tips on how to choose the appropriate solution, depending on the user's specific needs and requirements.

1. COMPARISON OF THE SPECIFICATIONS

Here is a table comparing the main specifications of the *Beamage-3.0-IR* and the *IR Adaptor*.

	BEAMAGE-3.0-IR (Camera)	IR ADAPTOR (Accessory)
Active Area	11.3 mm X 6.0 mm	27.5 mm Ø
IR Spectral Range	1495 nm – 1595 nm	1495 nm – 1595 nm
Peak IR Sensitivity	1510 nm and 1540 nm	1510 nm and 1540 nm
Converted Wavelengths	950 nm – 1075 nm	950 nm – 1075 nm
Pixel Multiplication Factor	1	3.29
Minimum Beam Size	70 µm	230 µm
Maximum Beam Size	6 mm	19 mm
Maximum Resolution	12 lp/mm over active area 40 lp/mm at sensor focal plane	12 lp/mm over active area 40 lp/mm at sensor focal plane
Distortion	1.0% barrel distortion	-1.0% barrel distortion (inverted image)
Linearity	Non-Linear, IR converted output ∝ IR input intensity ^1.41	Non-Linear, IR converted output ∝ IR input intensity ^1.41
Damage Threshold	1 W	1 W/cm²

Germany and Other Countries
Laser Components Germany GmbH
Tel: +49 8142 2864–0
Fax: +49 8142 2864–11
info@lasercomponents.com
www.lasercomponents.com

France
Laser Components S.A.S.
Tel: +33 1 39 59 52 25
Fax: +33 1 39 59 53 50
info@lasercomponents.fr
www.lasercomponents.fr

Nordic Countries
Laser Components Nordic AB
Tel: +46 31 703 71 73
Fax: +46 31 703 71 01
info@lasercomponents.se
www.lasercomponents.se

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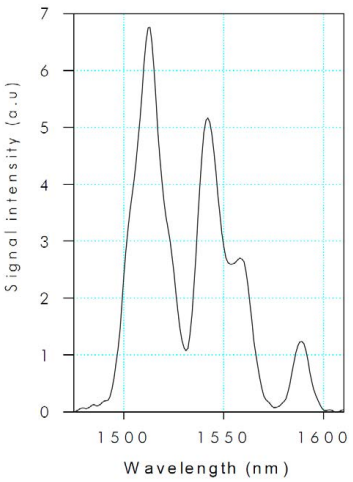
2. DETAILED COMPARISON

2.1. Spectral Range Sensitivity

Both options are exactly the same in terms of sensitivity accross the full spectral range. Indeed, the Phosphor coating applied on the sensor of *Beamage-3.0-IR* beam profiling camera is the same as the one used to cover the optics of the *IR Adaptor*. This coating allows NIR sensitivity because of a multi-photon absorption process in which less energetic photons of longer wavelengths are converted to more energetic photons of shorter (visible) wavelengths. Both the *Beamage-3.0-IR* and the *IR Adaptor* allow the profiling of laser beams that have wavelengths contained between 1495 nm and 1595 nm. The Phosphor coating has sensitivity peaks at 1510 nm and 1540 nm. Converted wavelengths are contained between 950 nm and 1075 nm and thus are detected by CMOS sensors.

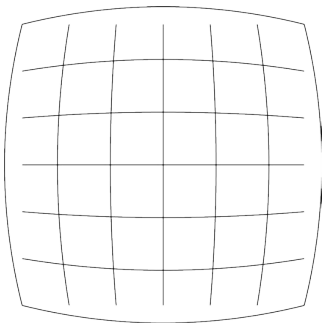


Phosphor Coating Excitation Spectrum

2.2. Image Quality

In terms of image quality, the *Beamage-3.0-IR* beam profiling camera offers a slightly better performance. The reason for this is that a beam that enters the device does not go through any optics that could create distortions, contrary to the *IR Adaptor* that has some optics, which can create small distortions such as speckles. These distortions are caused by the irregularities of the optical material. It is thus function of the quality of the material.

A good rule of thumb is that the less optics the beam goes through, the less distorted the image will be at the end of its propagation. It is also important to note that there is a barrel distortion created by the coating. In a barrel distortion, image magnification decreases with distance from the optical axis. The image appears to have been wrapped around a sphere or a barrel, as represented on the right. In the case of the B*eamage-3.0-IR* and *IR Adaptor*, it is as low as 1%. This value is the relative distortion associated with the distance between the center and the corner of the grid in the undistorted image and the same distance (smaller) in the distorted image.



Barrel Distortion Representation

Germany and Other Countries
Laser Components Germany GmbH
Tel: +49 8142 2864–0
Fax: +49 8142 2864–11
info@lasercomponents.com
www.lasercomponents.com

France
Laser Components S.A.S.
Tel: +33 1 39 59 52 25
Fax: +33 1 39 59 53 50
info@lasercomponents.fr
www.lasercomponents.fr

Nordic Countries
Laser Components Nordic AB
Tel: +46 31 703 71 73
Fax: +46 31 703 71 01
info@lasercomponents.se
www.lasercomponents.se

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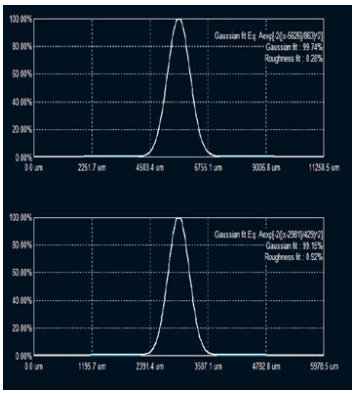
2.3. Beam Size (Diameter)

The minimum and maximum measurable beam sizes are different for both products. In the case of the *Beamage-3.0-IR* beam profiling camera, the minimum measurable beam size is approximately 70 µm at a 50% clip level, while it is around 55 µm for the *Beamage-3.0*. The reason for this difference is that any smaller beam will be significantly broadened by the point spread function (PSF) of the Phosphor coating. The PSF describes the response of an imaging system to a point source. The degree of spreading (blurring) of a point object is a measure of the quality of an imaging system. For the *Beamage-3.0-IR*, there should be no significant blurring if the 70 µm limit is respected. The maximum measurable beam size, on the other side, is limited by the dimensions of the CMOS sensor (11.3 mm X 6.0 mm).



X and Y Representations of a Beam

In the case of the *IR Adaptor*, larger beams can be imaged since the optics have magnification properties. The *Pixel Multiplication Factor (PMF)* is 3.29. In other words, the image generated by the optics of the *IR Adaptor* will be 3.29 times smaller than the object it is imaging. Therefore, the maximum measurable beam size is 19 mm, which is approximately 3.29 times the smallest dimension of the CMOS sensor. Using the same logic, the minimum measurable beam size is thus 230 µm.

2.4. Operating the Devices

Both options are relatively easy to use. However, the user has to follow a few more steps in order to perform a measurement when using an *IR Adaptor* in combination with a *Beamage-3.0* beam profiling camera. For example, it is necessary in that case to fix the devices together and to adjust the *Pixel Multiplication Factor* in the software. These steps and can be done easily by following the appropriate instructions in the *Beamage-3.0(-IR)* user manual or the *Beamage-3.0(-IR)* accessories manual.

It is possible to remove the *IR Adaptor* whenever the use of the camera alone is required. With the camera alone, it is possible to image lasers with wavelengths contained between 350 nm and 1150 nm, making it a more versatile solution. The Beamage-3.0-IR camera can only image lasers with wavelengths contained between 1495 nm and 1595 nm.

2.5. Cost

It is slightly more expensive to get an *IR Adaptor* and a *Beamage-3.0* beam profiling camera system than a *Beamage-3.0-IR* Phosphor coated camera alone.

Germany and Other Countries
Laser Components Germany GmbH
Tel: +49 8142 2864–0
Fax: +49 8142 2864–11
info@lasercomponents.com
www.lasercomponents.com

France
Laser Components S.A.S.
Tel: +33 1 39 59 52 25
Fax: +33 1 39 59 53 50
info@lasercomponents.fr
www.lasercomponents.fr

Nordic Countries
Laser Components Nordic AB
Tel: +46 31 703 71 73
Fax: +46 31 703 71 01
info@lasercomponents.se
www.lasercomponents.se

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3. CHOOSING THE APPROPRIATE OPTION

How to choose the appropriate solution?

The first thing to consider when selecting an option for your NIR applications is the spectral range. For users who are working exclusively with NIR lasers, the *Beamage-3.0-IR* beam profiling camera is definitely the best solution. It is less expensive and easier to use than a *Beamage-3.0* camera with an *IR Adaptor*. Also, there will be no trade-off on image quality.

However, if the NIR laser beam to be profiled is larger than the sensor of the camera (11.3 mm X 6.0 mm), the combination of the *Beamage-3.0* camera and an *IR Adaptor* is the appropriate solution, since, as mentioned earlier, this accessory has magnification properties. The combination of both products is also a better solution in terms of flexibility because it is possible at any time to remove the *IR Adaptor* from the camera and to use it separately to image beams with wavelengths contained between 350 nm and 1150 nm.

This option can be avoided by adding a *Camera Lens* to the *Beamage-3.0-IR* camera. The *Camera Lens* works by indirectly imaging on the sensor the reflection or the transmission of a beam that previously went through a diffusing material such as glass. With such technology, it is possible to image really large beams.

If you have questions about the *Beamage-3.0-IR* or the *IR Adaptor*, please feel free to contact us or your local Gentec-EO representative.

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Germany and Other Countries
Laser Components Germany GmbH
Tel: +49 8142 2864–0
Fax: +49 8142 2864–11
info@lasercomponents.com
www.lasercomponents.com

France
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Tel: +33 1 39 59 52 25
Fax: +33 1 39 59 53 50
info@lasercomponents.fr
www.lasercomponents.fr

Nordic Countries
Laser Components Nordic AB
Tel: +46 31 703 71 73
Fax: +46 31 703 71 01
info@lasercomponents.se
www.lasercomponents.se