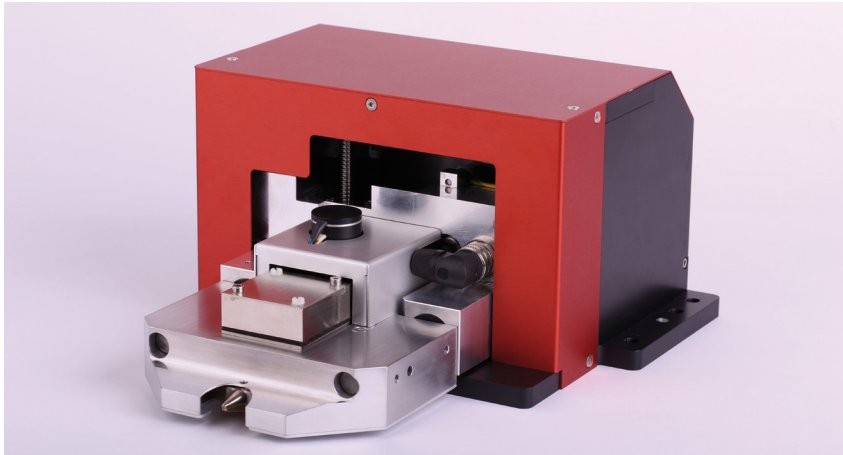


FocusMonitor FM



FocusMonitor FM35

The FocusMonitor (FM), a scanning diagnostics system for the analysis of continuous wave laser beams with low up to high laser beam powers, is used for the analysis of laser beam sources for laser material processing in laser beam welding, cutting as well as surface processing.

Not only the geometric dimensions of the focused laser beam are determined but also the focus position in space, the beam parameter product as well as the beam quality factor M^2 .

Provided that the limitations concerning the measuring window size as well as the maximum power density are kept, CO₂-laser systems with an optical power of up to 50 kW and solid-state lasers with an optical power of up to 30 kW can be measured.

Measuring Procedure – the Principle

The laser beam is scanned by means of a specialized measuring tip within a 3D measurement cylinder.

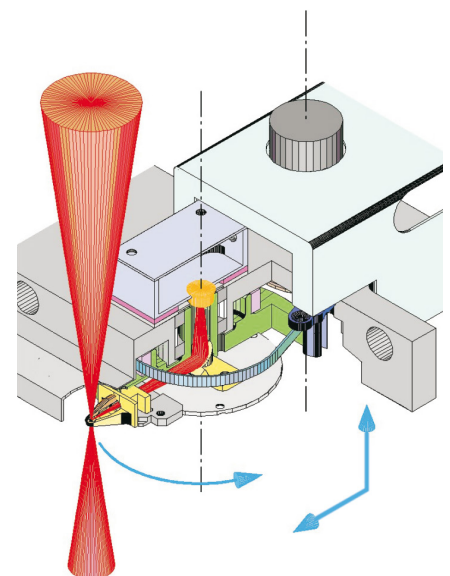
There is a small pin hole (typical diameter: 20 µm) in the measuring tip through which a small part of the laser beam is guided. By means of two deflecting mirrors this beam part is guided to a detector which is configured according to the laser power and the wavelength.

By means of the PRIMES LaserDiagnosticsSoftware it is then transferred to a computer in order to be evaluated. This 3D analysis is necessary for a complete presentation of a caustic close to the focus.

For different wavelengths pyroelectric detectors or photodiodes are used. The divergence of the focused laser beam of CO₂ lasers is rather small. The relationship between the focal length of the used focusing optic and the beam diameter of the unfocused beam, i.e. the effective F-number, is usually greater than 5.

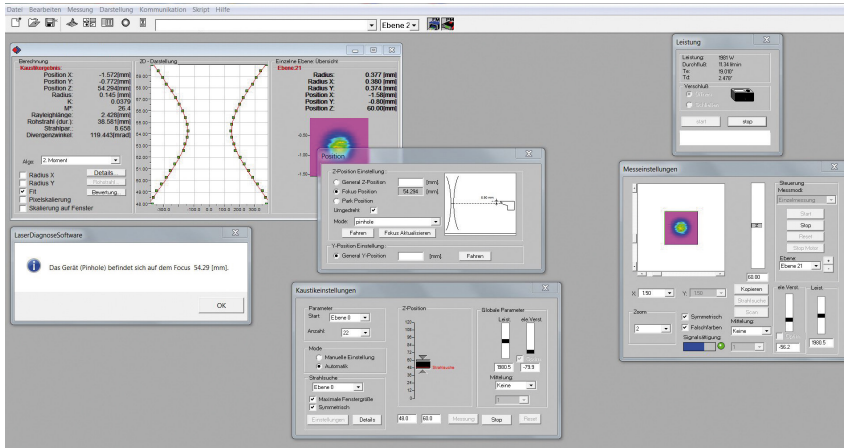
Solid-state lasers, such as diode-, disk- or fiber lasers are focused with smaller F-numbers. To cater for the resulting differences in divergence, adapted measuring tips are available.

Specially adapted measuring tips for different divergences and wavelengths are available.



Beam path of the optical signal within the FocusMonitor

FocusMonitor FM



Determination of the focus position in spatial coordinates with FM and LaserDiagnosticsSoftware

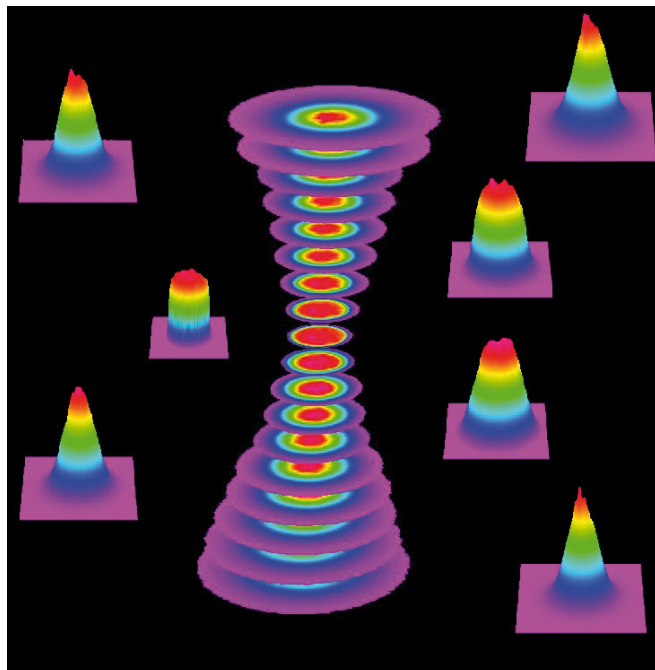
However, the signal-to-noise ratio must be > 40 . Detectors with dynamic ranges > 85 dB support this requirement. Please note that hardly no laser beam power is absorbed, more than 99 % of the power has to be absorbed separately after it passes through the FM.

This can be effected by means of PRIMES devices, such as the Power-Monitor PM48 or PM100.

Hence, different laser beam sources and -systems can be measured at maximum laser beam powers simply by choosing the right measuring tip and the suitable detector.

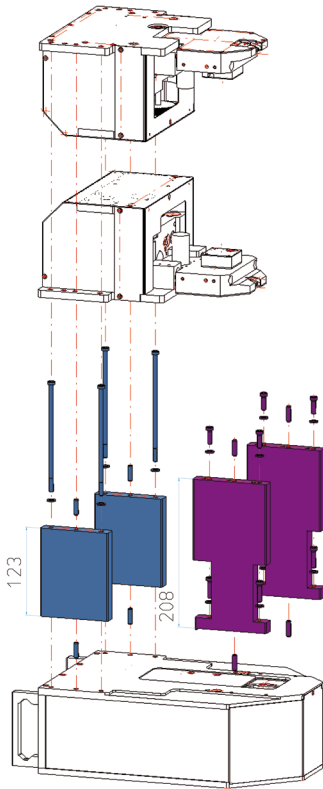
The high speed of the rotating measuring tip allows the analysis of high power densities. Due to the high dynamic range of the analog digital converter used, a very good signal-to-noise ratio is achieved.

High peak intensities as well as very low intensities are displayed precisely. This is one of the preconditions for an automatic measurement of caustics in the focus range over at least four Rayleigh lengths according to ISO 11146. This means that the power density along the laser beam axis varies at least around the factor 4 in this measurement range.



3D presentation of the measured caustic

FocusMonitor FM



Mounting of a FocusMonitor on a PowerMonitor 48

the menu <Communication>.

The selection of different interfaces and COM ports is effected manually.

In this start screen the revolutions per minute, measuring window sizes, detectors etc. are chosen in the menu <Sensor Parameter>. Focal width, wavelength, operator notes etc. are entered in the menu <Measuring Environment> in order to obtain a concise protocol alongside the measurements.

The resolution can be adjusted in steps between 32×32 up to 256×256 . At the same time the measurement window size can be adapted between 0.125 mm and 8 mm. This variation of resolution helps display even the smallest beam deformations due to contamination, aberrations, alignment errors, or thermal influences.

The scan range lies in the beam propagation direction z at 35 mm in case of the FM35 and at 120 mm in case of the FM 120. The measurement range transverse to the propagation direction is typically specified at 8×8 mm in x-y. As an option, larger measurement windows up to 24×12 mm are available.

The integrated z-axis enables the automatic measurement of complete caustics over four Rayleigh lengths. The number of measurement planes is freely selectable.

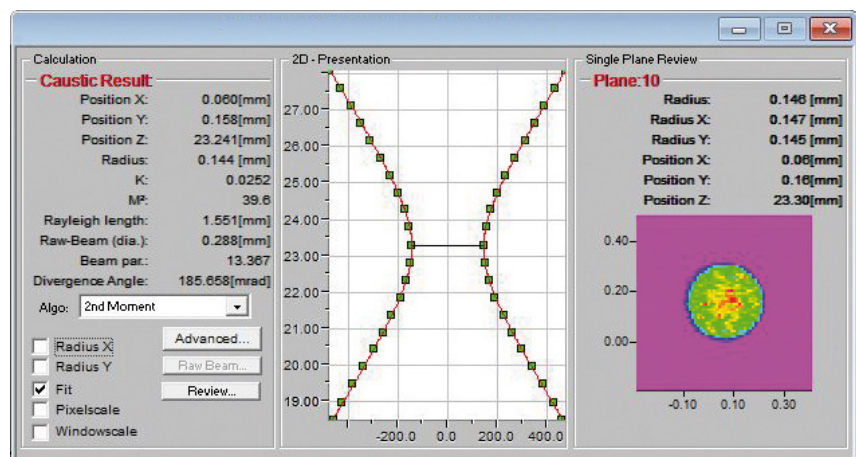
However, the number of planes is typically between 16 and 22. The graphical evaluation not only provides the geometrical dimensions but also the resulting beam quality factor M^2 at the work piece.

By means of the function <Store Measurement Settings> complete measurement programs can be stored and loaded again for further measurements with specified basic data as reference.

Operation

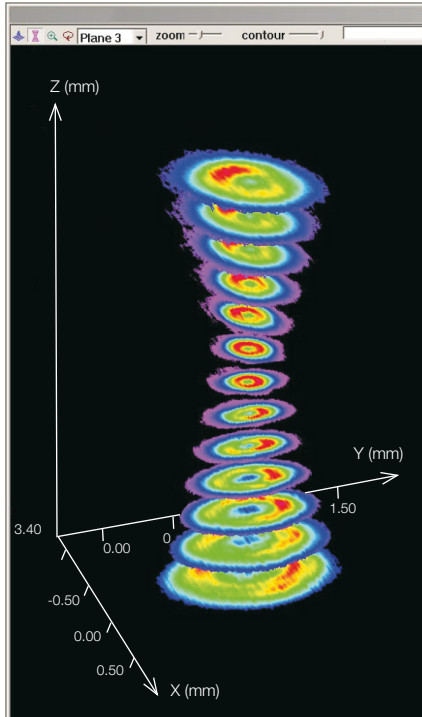
For the evaluation the PRIMES LDS – the LaserDiagnosticsSoftware – is provided. It runs, e.g., with the operating systems Windows XP or Windows 7 for example.

The FocusMonitor can communicate with computers or system controls via the PRIMES RS 485 bus. Details of this communication are visible and adjustable in the start screen as soon as <Free Communication> is selected in

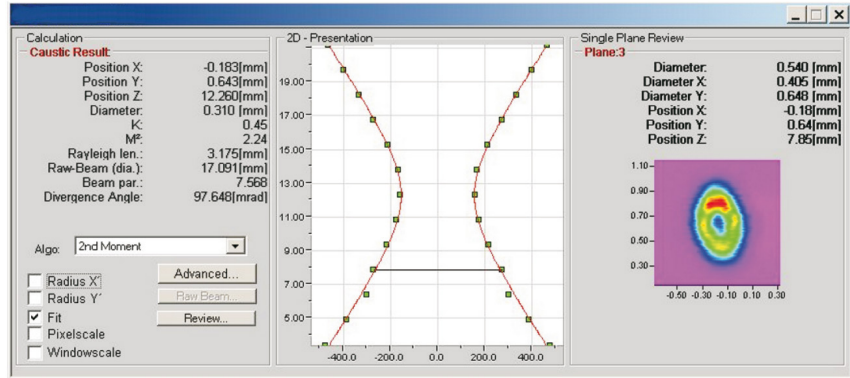


Presentation of the caustic measurement results of a 1 kW fiber laser

FocusMonitor FM



Astigmatic beam: false color presentation at different z-positions



Caustic of multikilowatt CO₂ laser, focussing mirror optics not positioned properly

For the analysis of solid-state lasers in the range between 800 and 1100 nm switchable DFY-2 detectors on the basis of photodiodes are employed. Recommended is the highly dynamic detector DFY-PS with an automatic signal adjustment. The DFING detector is available for wavelengths up to $\lambda = 2 \mu\text{m}$. These detectors are generally combined with a HighDiv. YAG measuring tip. There are additional DL measuring tips for diode lasers, which are mostly highly divergent.

In addition, specially adapted detectors, e.g. with an optimum signal-to-noise ratio or measuring tips with increased or reduced sensitivities can be provided.

Various evaluation possibilities provide information on faulty alignments of optical components and their contamination.

Measuring Tips and Detectors

Every FocusMonitor needs to be equipped with a suitable measuring tip and one detector. The replacement of both the detector and the measuring tip can be done in a few minutes.

For the wavelength range $\lambda = 10.6 \mu\text{m}$ of CO₂ lasers, mainly pyroelectric detectors DFCM together with HP-CO₂ measuring tips are employed.

Combination with the following detectors

Type	Laser	Detector	Rel. Amplification	Wavelength Range
DFCM	CO ₂	Pyro detector	1	9–12 μm
DFY-2	NIR/VIS	Photodiode	1 and 15	0.4–1.1 μm
DFY-PS	NIR/VIS	Photodiode	programmable	0.4–1.1 μm
DFING	NIR	Photodiode	1, 5, 25, 125 (625)	1–2.1 μm
DFH	CO ₂	Semiconductor	1	9–12 μm

Combination with the following measuring tips

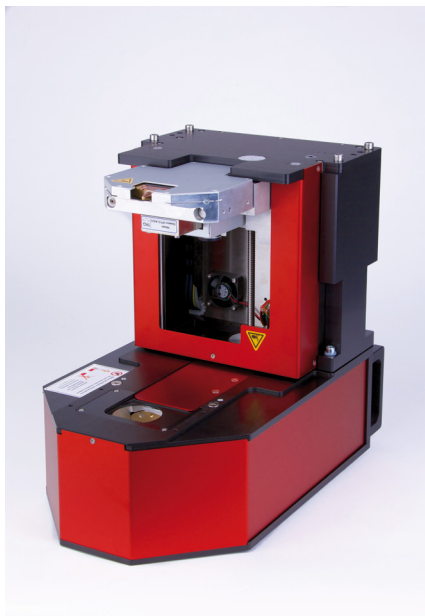
Type	Laser	Divergence	Power Density
HighDiv.YAG	Solid state lasers	up to 200 mrad	up to 10 MW/cm ²
HP-CO ₂	CO ₂ lasers	up to 240 mrad	up to 30 MW/cm ²
DL Diode	Diode lasers	up to 500 mrad	up to 1 MW/cm ²

FocusMonitor FM

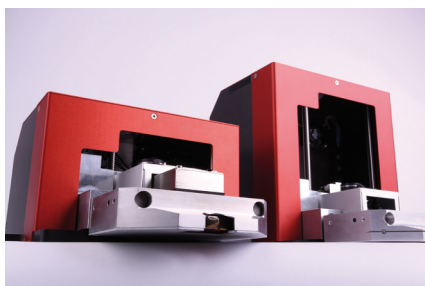
Configurations FM35 and FM120

The basic version of the FocusMonitor consists of one rotating axis with two revolutions (optionally 3) as well as two linear axes, one with a horizontal stroke of 8 mm (optionally 12 mm) and one with a vertical stroke of 35 mm or 120 mm.

The measurable focus diameter for both configurations ranges from 0.1 to 3 mm. Measurable Rayleigh lengths could reach 8 mm/25 mm. Thus, the FocusMonitor enables the measurement of a wide range of laser sources for various fields of applications.



Upside down mounting of a FM120 on a PM48



Left: FocusMonitor 35,
Right: FocusMonitor 120



Measuring tip in the FocusMonitor



Detector for the analysis
of 10.6 μm laser radiation

FocusMonitor FM

Technical Data

Measurement Parameters	
Power range	30–50,000 W
Wavelength range	0.4 – 12 μm
Beam dimensions typ.	150–3000 μm (up to 5000 μm optional)
Option: Small focus dimensions	100–150 μm
Determined Parameters	
Focus position x, y, z	yes
Focus radius x, y	yes
Beam propagation factor k	yes
Beam propagation ratio M^2	yes
Measured Rayleigh length, typ.	8 mm (FM35) 28 mm (FM120)
Raw beam diameter with focussing element	yes
Beam parameter product	yes
Divergence angle	yes
Peak intensities in combination with PowerMonitor	CO ₂ laser: 30 MW/cm ² NIR laser: 10 MW/cm ²
Power density distribution	2D, 3D
Evaluation 86 % (1/e ²)	yes
Evaluation 2nd moment	yes
Automatic measuring range > 4 rayleigh lengths	optional
Measurement time/low res. plane (32 x 32 pixel)	3 s
Measurement time/high res. plane (256 x 256 pixel)	30 s
Function of the Measuring System	
Working range x-y	8 x 8 mm / 12 x 12 mm (12 x 24 mm optional)
Working range z	35 mm (FM35) 120 mm (FM120)
Measurement window sizes	0.08 x 0.08 – 12 x 24 mm (resolution 64 pixel)
Resolution	32 x 32 – 256 x 256 pixel
Rotation speed	1875, 3750 rpm (7500 rpm optional)
Line focus	yes
Linescan	optional
Supply Data	
Power supply	24 V DC \pm 5 %, max. 4 A
Protective gas	typ. 0.5 bar
Communication	
Interfaces	RS485, RS232 with USB, serial
Trigger-delay port	optional
Dimensions and Weight	
Dimensions (L x W x H)	276 x 242 x 131 mm (FM35) 276 x 242 x 216 mm (FM120)
Weight	6 kg (FM35) 7.2 kg (FM120)
Environmental Conditions	
Operating temperature range	+10°C up to +40°C
Permissible relative humidity (non-condensing)	10 – 80 %



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