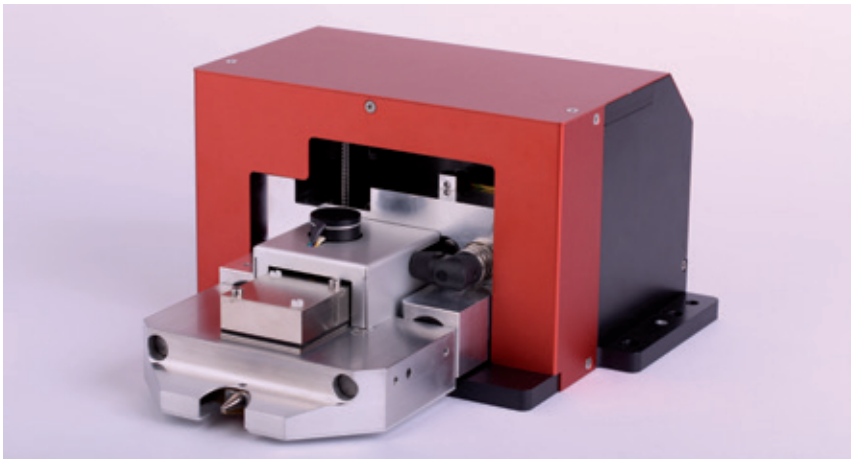
# FocusMonitor FM



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, $CO_2$-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.

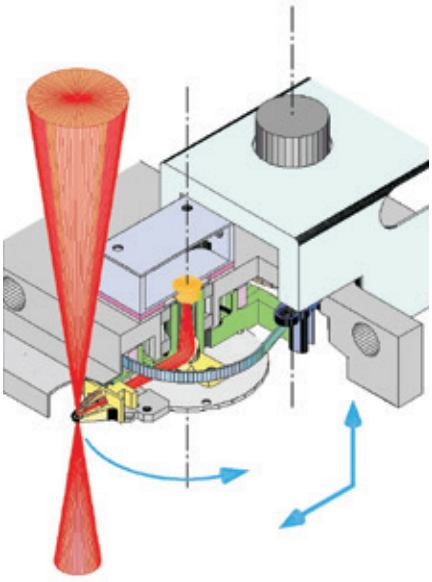
There is a small pin hole (typical diameter: 20 µm) in the measuring tip through which a small part of the laser beam is guided. By means of two deflecting mirrors this beam part is guided to a detector which is configured according to the laser power and the wavelength.

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 $CO_2$ 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.

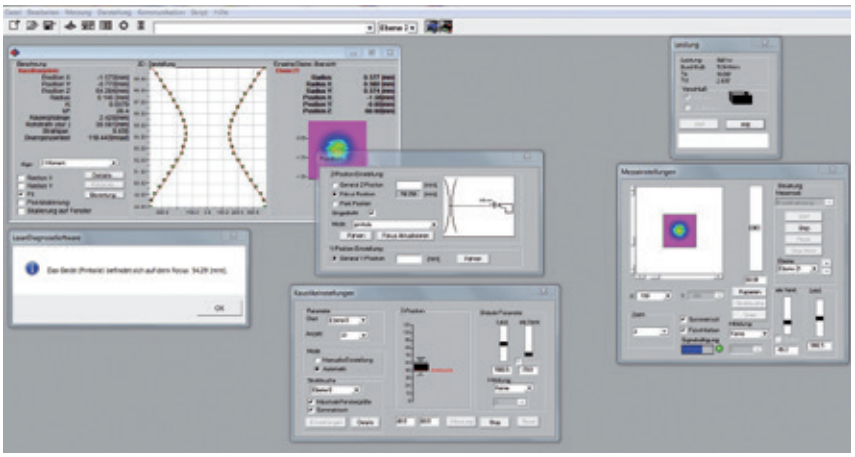
Solid-state lasers, such as diode-, disk- or fiber lasers are focused with smaller F-numbers. To cater for the resulting differences in divergence, adapted measuring tips are available.

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**

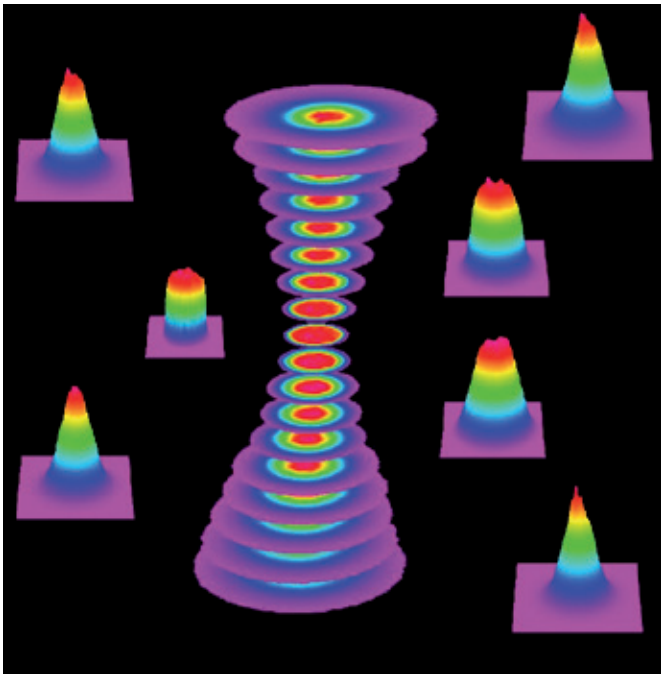
However, the signal-to-noise ratio must be > 40. Detectors with dynamic ranges > 85 dB support this requirement. Please note that hardly no laser beam power is absorbed, more than 99 % of the power has to be absorbed separately after it passes through the FM.

This can be effected by means of PRIMES devices, such as the PowerMonitor 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.

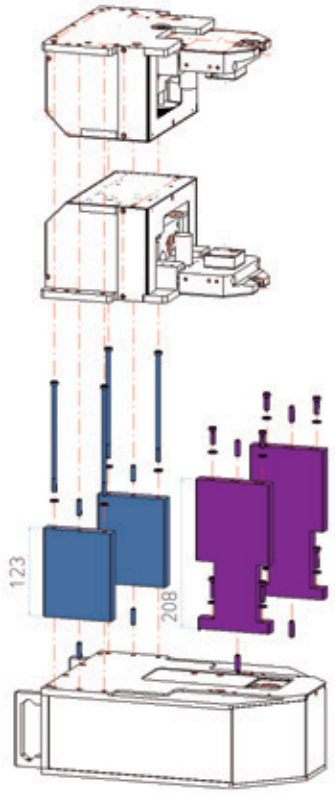
The high speed of the rotating measuring tip allows the analysis of high power densities. Due to the high dynamic range of the analog digital converter used, a very good signal-to-noise ratio is achieved.

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 FM120. 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.

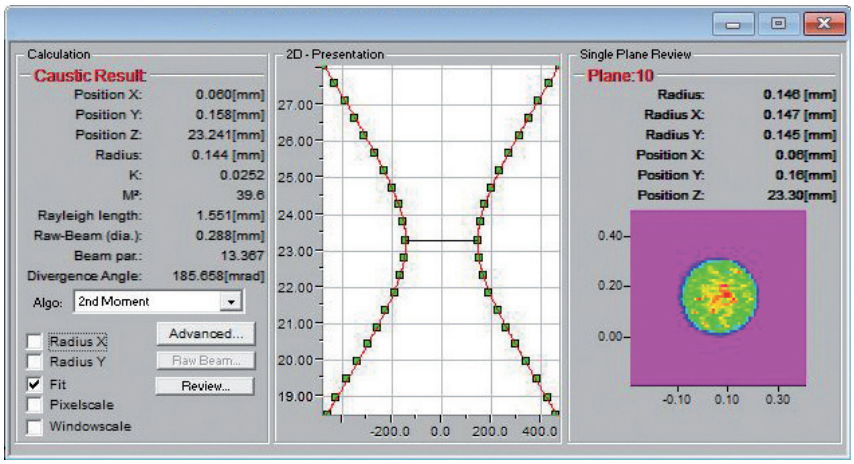
However, the number of planes is typically between 16 and 22. The graphical evaluation not only provides the geometrical dimensions but also the resulting beam quality factor $M^2$ at the work piece.

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

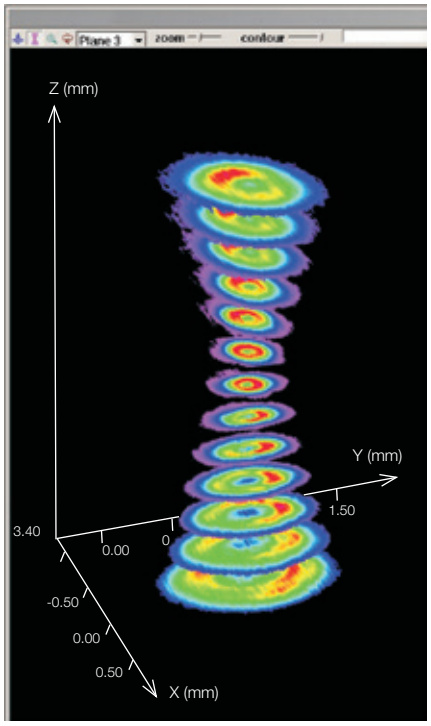
For the evaluation the PRIMES LDS – the LaserDiagnosticsSoftware – is provided. It runs, e.g., with the operating systems Windows XP or Windows 7 for example.

The FocusMonitor can communicate with computers or system controls via the PRIMES RS485 bus. Details of this communication are visible and adjustable in the start screen as soon as <Free Communication> is selected in

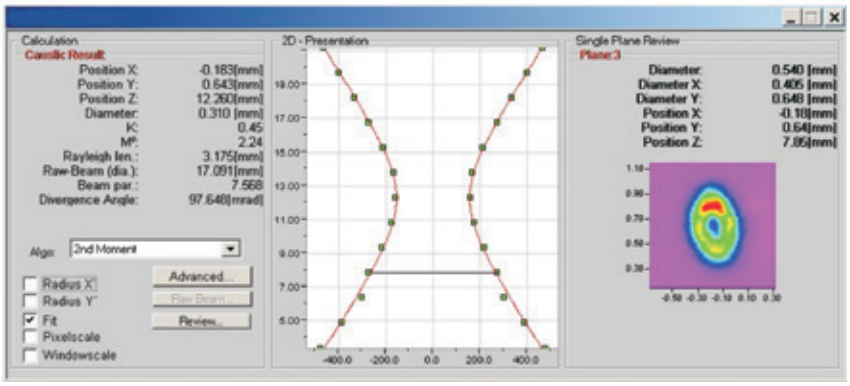



**Presentation of the caustic measurement results of a 1 kW fiber laser**

# FocusMonitor FM




**Astigmatic beam: false color presentation at different z-positions**




**Caustic of multikilowatt $CO_2$ laser, focussing mirror optics not positioned properly**

## 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 λ=10.6 µm of $CO_2$ lasers, mainly pyroelectric detectors DFCM together with HP-$CO_2$ measuring tips are employed.

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 λ=2 µm. 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.

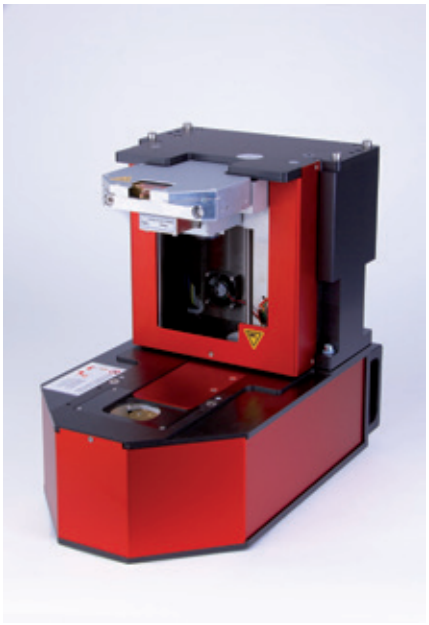
In addition, specially adapted detectors, e.g. with an optimum signal-to-noise ratio or measuring tips with increased or reduced sensitivities can be provided.

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

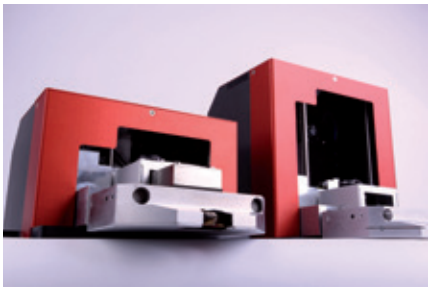
| Combination with the following detectors | | | | |
|---|---|---|---|---|
| **Type** | **Laser** | **Detector** | **Rel. Amplification** | **Wavelength Range** |
| DFCM | $CO_2$ | Pyro detector | 1 | 9–12 µm |
| DFY-2 | NIR/VIS | Photodiode | 1 and 15 | 0.4–1.1 µm |
| DFY-PS | NIR/VIS | Photodiode | 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/cm² |
| HP-$CO_2$ | $CO_2$ lasers | up to 240 mrad | up to 30 MW/cm² |
| DL Diode | Diode lasers | up to 500 mrad | up to 1 MW/cm² |

# FocusMonitor FM



Upside down mounting of a FM120 on a PM48



Left: FocusMonitor 35,
Right: FocusMonitor 120

## 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.

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)<br>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/cm²<br>NIR laser: 10 MW/cm² |
| 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)<br>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 ± 5 %, max. 5 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)<br>276 x 242 x 216 mm (FM120) |
| Weight | 6 kg (FM35)<br>7.2 kg (FM120) |
| **Environmental Conditions** | |
| Operating temperature range | +10°C up to +40°C |
| Permissible relative humidity (non-condensing) | 10 – 80 % |

# FocusMonitor FM

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