PRIMES

Operating Manual

Translation of the original instructions

FocusMonitor FM+

LaserDiagnosticsSoftware LDS

Revision 03/2019 EN

IMPORTANT!

READ CAREFULLY BEFORE USE.

KEEP FOR FUTURE USE.

Table of contents

PRIMES - The Company

PRIMES manufactures measuring devices used to analyze laser beams. These devices are employed for the diagnostics of high-power lasers ranging from CO_2 lasers and solid-state lasers to diode lasers. A wavelength range from infrared through to near UV is covered, offering a wide variety of measuring devices to determine the following beam parameters:

- Laser power
- Beam dimensions and position of an unfocused beam
- Beam dimensions and position of a focused beam
- Beam quality factor M^2

PRIMES is responsible for both the development, production, and calibration of the measuring devices. This guarantees optimum quality, excellent service, and a short reaction time, providing the basis for us to meet all of our customers' requirements quickly and reliably.

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1 Basic safety instructions

Intended Use

The FocusMonitor FM+ has been designed exclusively for measurements carried out in or near the optical path of high-power lasers. Please observe and adhere to the specifications and limit values given in chapter 16, „Technical data“, on page 42. Other uses are considered to be improper. The information contained in this operating manual must be strictly observed to ensure proper use of the device.

Using the device for unspecified use is strictly prohibited by the manufacturer. By usage other than intended the device can be damaged or destroyed. This poses an increased health hazard up to fatal injuries. When operating the device, it must be ensured that there are no potential hazards to human health.

The device itself does not emit any laser radiation. During the measurement, however, the laser beam is guided onto the device which causes reflected radiation (**laser class 4**). That is why the applying safety regulations are to be observed and necessary protective measures need to be taken.
Observing applicable safety regulations

Please observe valid national and international safety regulations as stipulated in ISO/CEN/TR standards as well as in the IEC-60825-1 regulation, in ANSI Z 136 “Laser Safety Standards” and ANSI Z 136.1 “Safe Use of Lasers”, published by the American National Standards Institute, and additional publications, such as the “Laser Safety Basics”, the “LIA Laser Safety Guide”, the “Guide for the Selection of Laser Eye Protection” and the “Laser Safety Bulletin”, published by the Laser Institute of America, as well as the “Guide of Control of Laser Hazards” by ACGIH.

Necessary safety measures

DANGER

Serious eye or skin injury due to laser radiation

Depending on the measuring principle used, the laser beam is reflected at the measuring tip (laser class 4). The reflected beam is usually not visible.

- ▶ **In measurement mode, a safety distance of one meter to the FocusMonitor FM+ must be maintained even when wearing safety goggles and safety clothing.**
- ▶ **Please take the following precautions.**

If people are present within the danger zone of visible or invisible laser radiation, for example near laser systems that are only partly covered, open beam guidance systems, or laser processing areas, the following safety measures must be implemented:

- Please wear **safety goggles (OD 6)** adapted to the power, power density, laser wave length and operating mode of the laser beam source in use.
- Depending on the laser source, it may be necessary to wear suitable **protective clothing** or **protective gloves**.
- Protect yourself from direct laser radiation, scattered radiation, and beams generated from laser radiation (by using appropriate shielding walls, for example, or by weakening the radiation to a harmless level).
- Use beam guidance or beam absorber elements that do not emit any hazardous substances when they come in to contact with laser radiation and that can withstand the beam sufficiently.
- Install safety switches and/or emergency safety mechanisms that enable immediate closure of the laser shutter.
- Ensure that the device is mounted securely to prevent any movement of the device relative to the beam axis and thus reduce the risk of scattered radiation. This in the only way to ensure optimum performance during the measurement.

Employing qualified personnel

The device may only be operated by qualified personnel. The qualified personnel must have been instructed in the installation and operation of the device and must have a basic understanding of working with high-power lasers, beam guiding systems and focusing units.

Conversions and modifications

The device must not be modified, neither constructionally nor safety-related, without our explicit permission. The device must not be opened e.g. to carry out unauthorized repairs. Modifications of any kind will result in the exclusion of our liability for resulting damages.

Liability disclaimer

The manufacturer and the distributor of the measuring devices do not claim liability for damages or injuries of any kind resulting from an improper use or handling of the devices or the associated software. Neither the manufacturer nor the distributor can be held liable by the buyer or the user for damages to people, material or financial losses due to a direct or indirect use of the measuring devices.

2 Symbol explanations

The following symbols and signal words indicate possible residual risks:

DANGER

Means that death or serious physical injuries **will** occur if necessary safety precautions are not taken.

WARNING

Means that death or serious physical injuries **may** occur if necessary safety precautions are not taken.

CAUTION

Means that minor physical injury **may** occur if necessary safety precautions are not taken.

NOTICE

Means that property damage **may** occur if necessary safety precautions are not taken.

The following symbols indicating requirements and possible dangers are used on the device:

Laser radiation warning

Hand injuries warning

Read and observe the operating instructions and safety guidelines before startup!

Further symbols that are not safety-related:

Here you can find useful information and helpful tips.

With the CE designation, the manufacturer guarantees that its product meets the requirements of the relevant EC guidelines.

▶ Call for action

3 About this operating manual

This documentation describes the installation and configuration of the FocusMonitor FM+ and the execution of measurements with the LaserDiagnosticsSoftware LDS.

The LaserDiagnosticsSoftware LDS must be installed on the PC for measuring operation of the FocusMonitor FM+. The basic version of the LaserDiagnosticsSoftware LDS is included in the scope of delivery for the device.

For a detailed description of the software installation, file management and evaluation of the measured data, please refer to the separate operating manual LaserDiagnosticsSoftware LDS.

4 Conditions at the installation site

- The device must not be operated in a condensing atmosphere.
- The ambient air must be free of organic gases.
- Protect the device from splashes of water and dust.
- Operate the device in closed rooms only.

DANGER

Fire and explosion hazards due to scattered or directed laser radiation

When the FocusMonitor FM+ is being operated, the irradiation must be fully absorbed behind the measurement zone. Fire bricks or other partly-absorbing surfaces are not suitable.

- ▶ **Use an adequate absorber. Dependent on the application, PRIMES offers suitable absorbers, such as the PowerMonitor PM 48/100.**
- ▶ **Don’t store any flammable materials or highly flammable substances at the measuring location.**

5 Introduction

5.1 System description

The FocusMonitor FM+ is an opto-mechanical scanning measurement system for analyzing continuous irradiation. The laser beam is scanned with a rotating measuring tip on the x-axis. Using the horizontal and vertical carriers, the measuring tip is moved along the y- and z-axes so that the beam characteristics of the focused laser beam can be spacially measured.

The housing of the FocusMonitor FM+ is symmetrically constructed so that it can be mounted overhead without additional components.

The FocusMonitor FM+ has an Ethernet interface for fast and secure data exchange with computers or system controls.

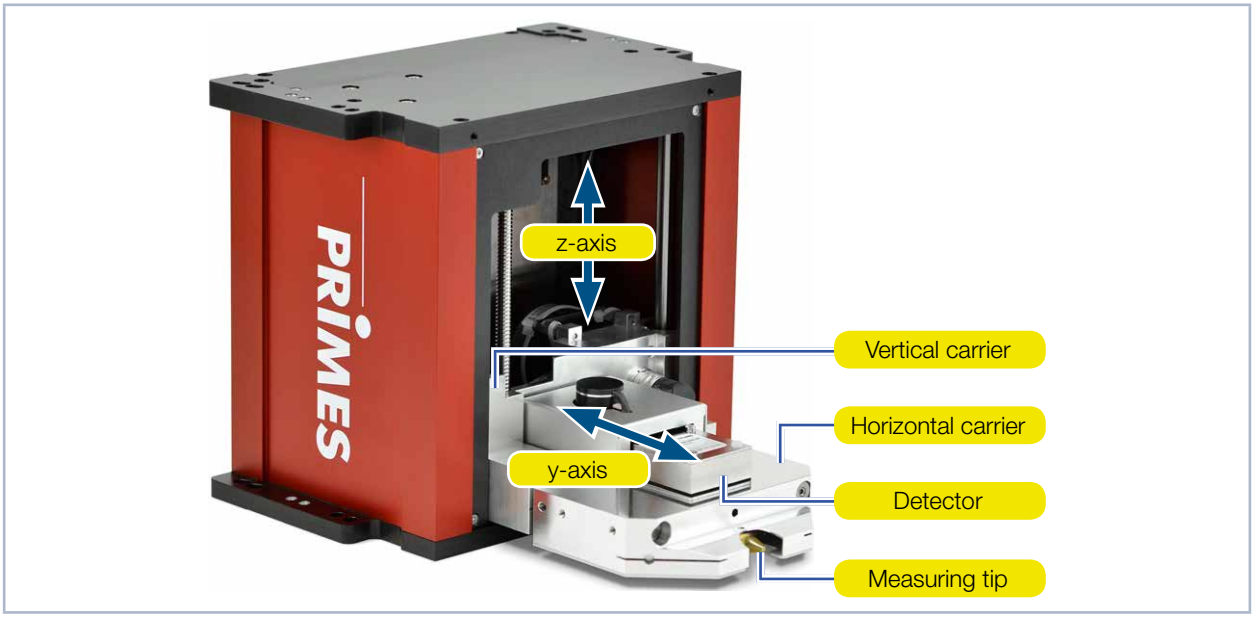


Fig. 5.1: Main components FocusMonitor FM+

5.2 Measuring principle

The FocusMonitor FM+ is designed to analyze the focused laser beam. The device measures the spatial power density distribution in the focus range of the processing optics. Using this information, the system calculates the focus radius, focus position in the space, and the beam quality factor M^2.

The power density distribution in the focus is measured with the FocusMonitor FM+ using a rotating measuring tip that scans the beam cross section line by line in the y-direction. The tiny aperture of the measuring tip (pinhole) separates out a small part of each beam. Mirrors then guide the measuring signal to a detector. The measuring system can be moved automatically via an integrated z-axis. This ensures that the propagation parameters can be determined in full by moving along the beam caustic.

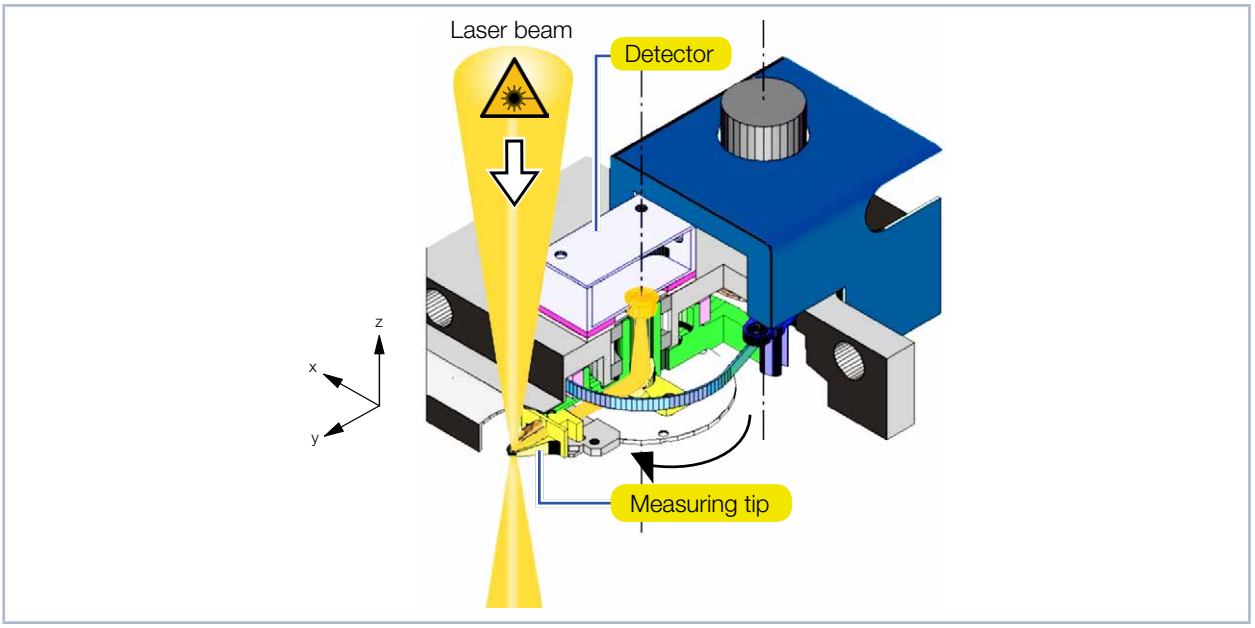


Fig. 5.2: Optomechanical design of the FocusMonitor FM+

The use of different detectors and measuring tips ensure that the FocusMonitor FM+ can be adjusted to specific beam diagnosis requirements within a broad wavelength and power density range. The system applications range from a few MW/cm² up to a few W/cm². Detailed descriptions of other detectors and measuring tips (e.g. suitable for the detection of strongly divergent beams, such as those generated by high-power diode lasers) can be found in chapter 18.2 on page 47.

5.3 Short overview installation

1. Installing the LaserDiagnosticsSoftware LDS on the computer • Software is part of the scope of delivery	See separate Operating Manual of the LaserDiagnosticsSoftware LDS
2. Taking safety precautions	Chapter 1 on page 7
3. Prepare Installation • Observe safety instructions • Make preparations • Set installation position	Chapter 7.1 on page 14 to chapter 7.3 on page 17
4. Electrical connection • Establish voltage supply	Chapter 8 on page 21
5. Connect with the computer • Via Ethernet or LAN	Chapter 8.3 on page 23
6. Connect with the PowerMonitor PM 48/100 • Via RS485	Chapter 8.4 on page 24
7. Inert gas connection • At very high power density (CO_2 > 15 – 30 MW/cm²; NIR > 8 – 10 MW/cm²)	Chapter 9 on page 25
8. Complete installation • Align the device • Mount the device firmly	Chapter 7.4 on page 18 and chapter 7.5 on page 20
9. Perform the measurement • Observe safety instructions • Configure FocusMonitor FM+ • Perform a sample measurement	Chapter 11 on page 26

6 Transport

NOTICE

Damage/Destruction of the device

The device's axes and carriers may be damaged if the device is subjected to hard shocks or is allowed to fall.

- ▶ **Handle the device carefully when transporting or installing it.**
- ▶ **Only transport the device in the original PRIMES transport box.**

We recommend removing the measuring tip and placing it in the enclosed plastic case.

7 Installation

7.1 Safety instructions

Areas on the device that could be particularly hazardous for hand injuries are marked with the following pictogram:

Hand injuries warning

CAUTION

Risk of injury caused by rotating parts

The measuring tip of the FocusMonitor FM+ rotates at high speed during the measuring operation. Even after the motor has been turned off, the measuring tip will continue to rotate for a certain amount of time.

- ▶ **Do not reach into or hold any objects into the beam entrance of the measuring device (see Fig. 7.1 on page 15).**
- ▶ **After the motor has been turned off, wait until the measuring tip comes to a complete stop (pay attention to the status display on the connection side).**

CAUTION

Risk of crushing

Unlike the housing, the measuring head of the FocusMonitor FM+ can move along the z- and y-axis.

- ▶ **Do not reach into the movement range of the measuring head (see Fig. 7.2 on page 15).**

Fig. 7.1: Danger posed by rotating parts

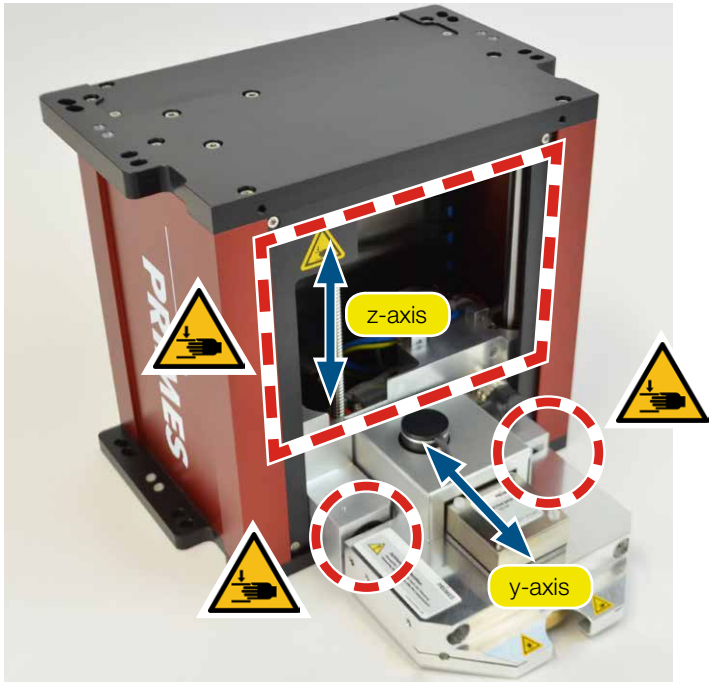


Fig. 7.2: Crushing hazard at the FocusMonitor FM+

7.2 Preparation

Before installation, check the available space, especially to ensure that there is enough room for the movement range of the FocusMonitor FM+.
The device must be firmly assembled and must be mounted with screws (see chapter 7.5 on page 20). Its symmetrical construction allows the device to be set up and mounted overhead without additional aids. The position and diameter of the mounting holes on the top/bottom are identical.

NOTICE

Damage/Destruction of the device

Obstacles in the movement range of the FocusMonitor FM+ can lead to collisions and damage the device.

- **Keep the movement range free of obstacles (cutting nozzle, pressure rolls, etc.). Please note that the measuring head automatically moves into its resting position after the power supply has been turned off and on again or following a reset. Keep this area clear.**

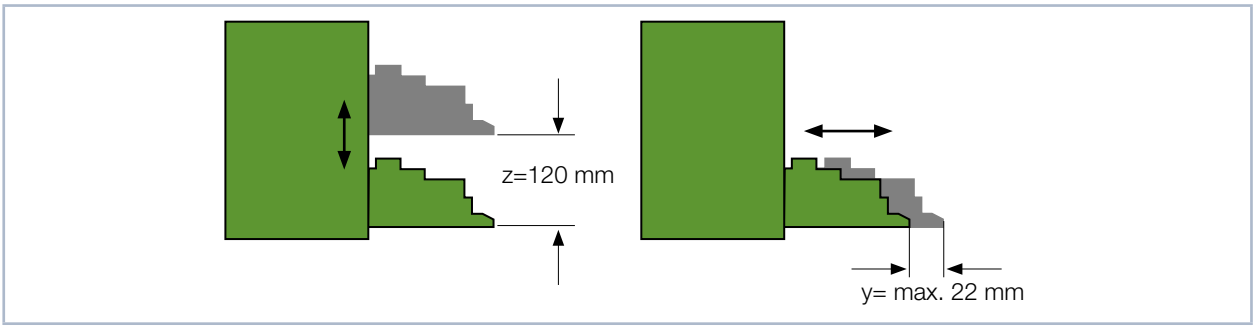


Fig. 7.3: Movement range of the measuring head

In the LaserDiagnosticsSoftware LDS you have the option to restrict the movement range of the FocusMonitor FM+ (locked area, for further informationen see chapter 11.4.4 on page 32).

DANGER

Fire and explosion hazards due to scattered or directed laser radiation

When the FocusMonitor FM+ is being operated, the irradiation must be fully absorbed behind the measurement zone. Fire bricks or other partly-absorbing surfaces are not suitable.

- **Use an adequate absorber. Dependent on the application, PRIMES offers suitable absorbers, such as the PowerMonitor PM 48/100.**
- **Don't store any flammable materials or highly flammable substances at the measuring location.**

NOTICE

Damage/Destruction of the absorber (e. g. PowerMonitor PM 48/100)

If the focused laser hits the absorber, it may be destroyed.

- **Ensure there is enough distance between the FocusMonitor FM+ and the absorber (the maximum permissible power density of the absorber must not be exceeded).**

7.3 Installation position

You can install the device in different positions (see Fig. 7.4 on page 17). The standard position is intended for beam incidence from above.
When accessibility is limited, you have the option of installing the device upside down with a rotated measuring tip (see chapter 18.5 on page 52).

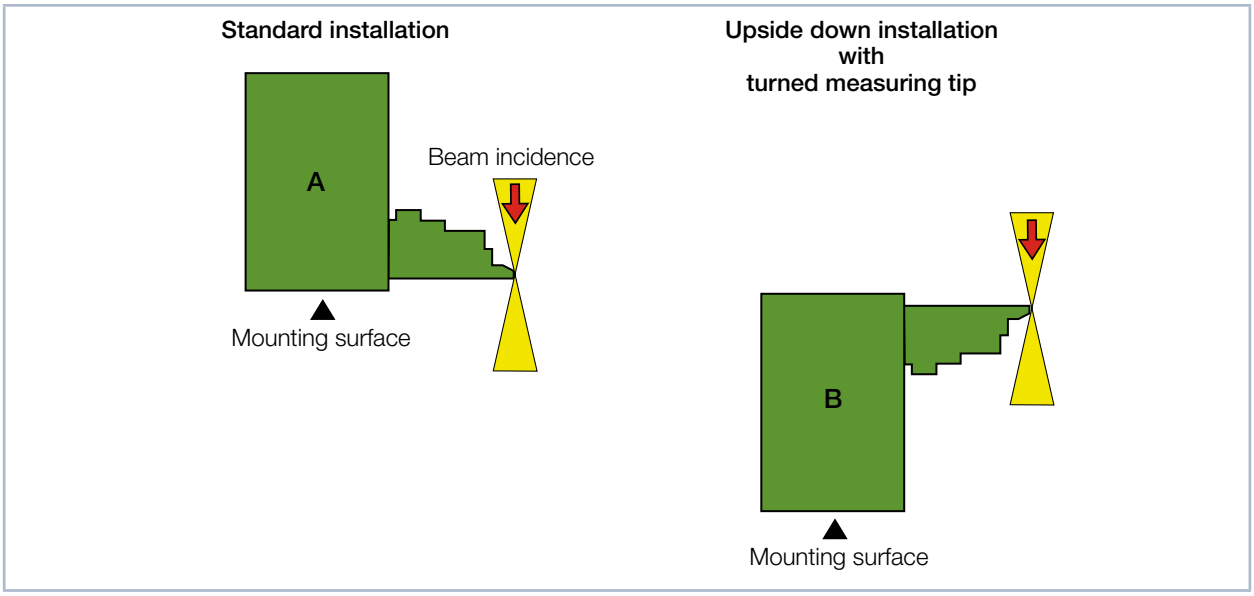


Fig. 7.4: Mounting options for the FocusMonitor FM+

To prevent transport damage, the measuring tip is disassembled when delivered. It is installed with the curved part facing towards the beam source (see Fig. 7.5 on page 17). Further information on mounting the measuring tip is provided in chapter 18.5 on page 52.

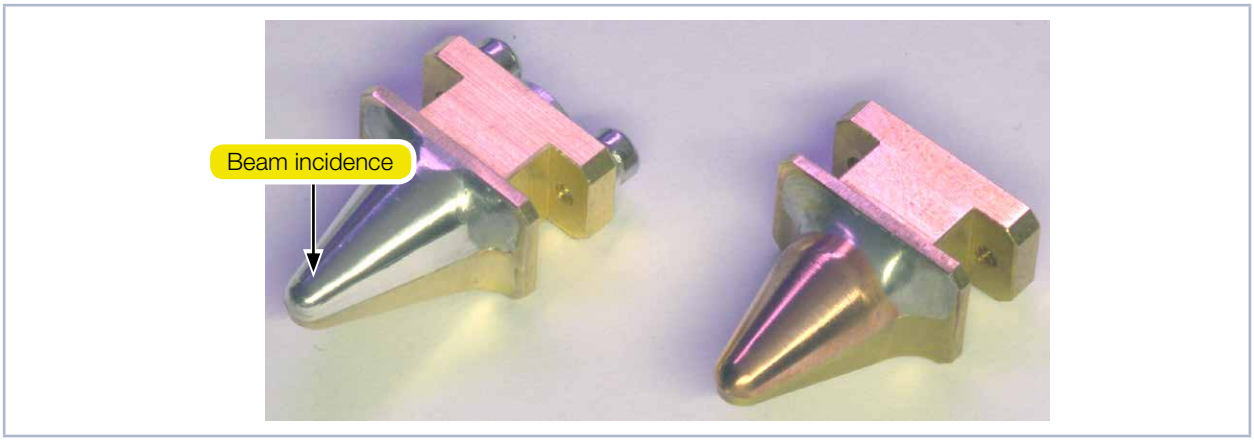


Fig. 7.5: Direction of the measuring tip during installation

The FocusMonitor FM+ can also be mounted on a vertical surface so that it can be operated with the beam entering horizontally. Ensure that it is fastened securely in the horizontal direction.

7.4 Align the FocusMonitor FM+

7.4.1 Device's position in relation to the laser beam

For the FocusMonitor FM+, the beam must enter vertically to the x-y-plane (see Fig. 7.6 on page 18).

The vertical alignment (z-axis) is primarily dependent on the expected focal length. The maximum vertical stroke of the measuring device is 120 mm.

The beam focus should be in the middle of the movement range of the z-axis. This is approx. 60 mm above the resting position of the measuring head (see Fig. 7.6 on page 18).

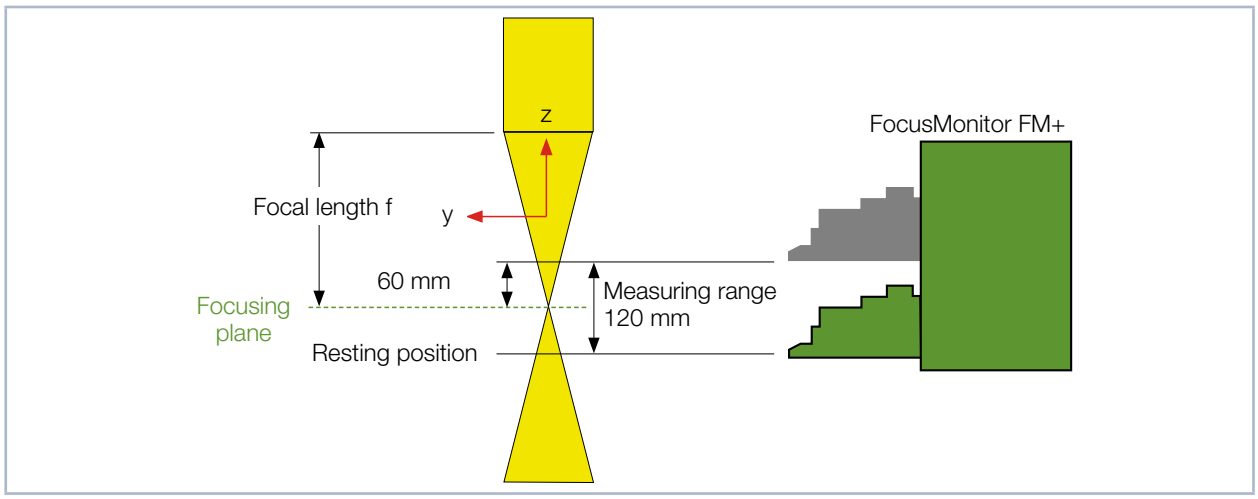


Fig. 7.6: Measuring range of FocusMonitor FM+

7.4.2 Align the FocusMonitor FM+ with the alignment tool

An alignment tool (see Fig. 7.7 on page 19) is provided with every device to ensure the seamless alignment (x-y plane) with the laser beam. The alignment tools differ depending on the size of the measuring window. The offset (distance from the aperture in the measuring tip (pinhole) in the resting position to the middle of the measuring window in the y-direction) is given on the alignment tool (see Fig. 7.8 on page 19).

⚠ CAUTION

Risk of injury caused by rotating or moving parts

The linear movement of the horizontal and vertical carriers and the rotating measuring tip pose an injury hazard.

- ▶ **Do not place your hand in the traversing range of the measuring head.**
- ▶ **Only align the FocusMonitor FM+ while the measuring tip is stationary.**

1. Connect the FocusMonitor FM+ with the LaserDiagnosticsSoftware LDS as described in chapter 11.3 on page 28.
2. Choose the function of the FocusMonitor FM+ as described in chapter 11.4.1 on page 29.
3. In accordance with chapter 11.4.3 on page 31, enter the value of 60 mm in the ***Device Control > Advanced > Move axes*** menu.

- The horizontal carrier will move to the position 60 mm above its resting position (see Fig. 7.6 on page 18) without a rotated measuring tip.

4. Place the alignment tool on the measuring head.
5. Turn on the pilot laser and align the device:

- If the laser beam hits perpendicular to and in the middle of the small marking in the alignment tool, the device is properly aligned.

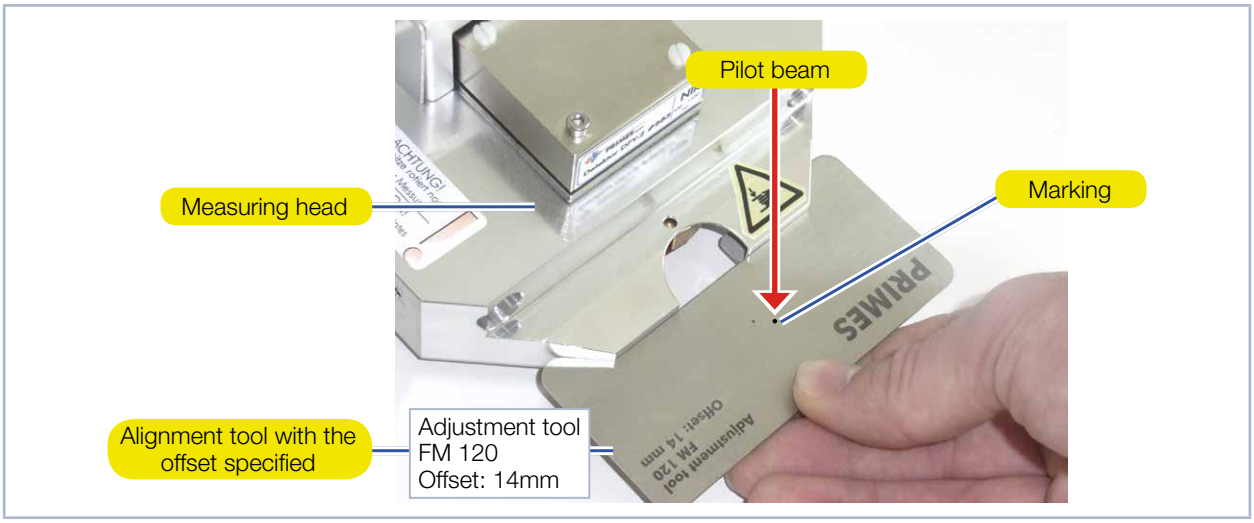


Fig. 7.7: Alignment tool at the measuring head of FocusMonitor FM+

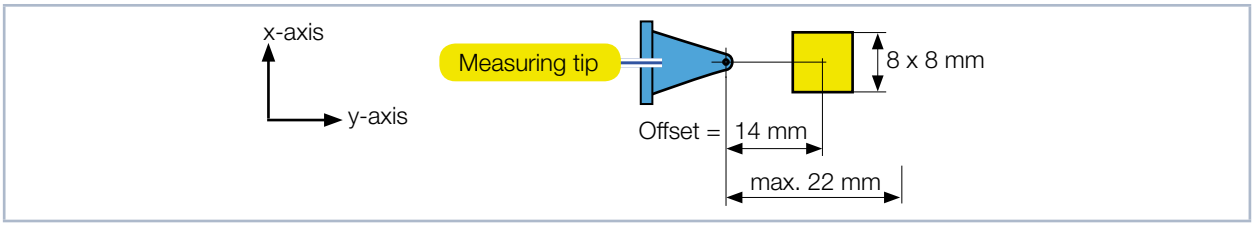


Fig. 7.8: Offset of a measurement window size of 8 x 8 mm

NOTICE

Damage/destruction of the alignment tool

The exposure with laser radiation will destroy the alignment tool.

▶ **Remove the alignment tool before turning on the laser.**

Five to twelve seconds after the supply voltage is switched on, the FocusMonitor FM+ moves into the resting position (lowest z-position).

7.5 Install the FocusMonitor FM+

DANGER

Serious eye or skin injury due to laser radiation

If the device is moved from its calibrated position, increased scattered or directed reflection of the laser beam occurs during measuring operation (laser class 4).

- ▶ **Mount the device so that it cannot be moved by an unintentional knock or cables being pulled accidentally.**

The mounting surface of the housing has six slotted holes Ø 6.4 mm and four alignment holes Ø 6^{G7} mm for assembly on a support bracket provided by the customer (see Fig. 7.9 on page 20).
Use at least four M6 screws to fasten the housing.
The total length of the screws depends on the dimensions of the customer's support bracket.
The dimensioned arrangement of the mounting holes is specified in chapter 17, „Dimensions", on page 44.

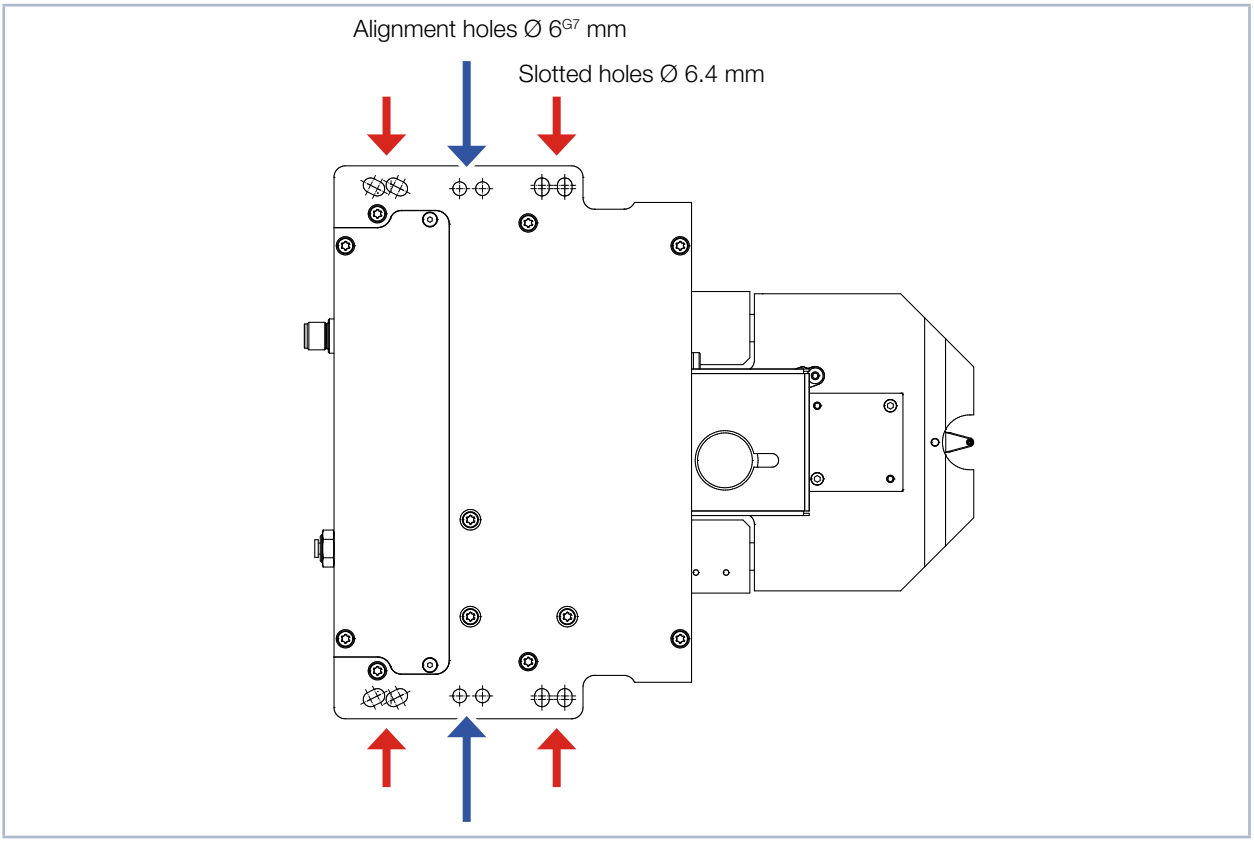


Fig. 7.9: Mounting holes, view from above (same hole pattern below)

NOTICE

Damage/Destruction of the measuring tip

If the laser beam hits the measuring tip in the beam path, it could be destroyed.

- ▶ **Remove the measuring tip from the beam path following installation.**

8 Electrical connections

The FocusMonitor FM+ requires a voltage supply of 24 V ±5 % (DC) for the operation. A suitable power supply is included in the scope of delivery.

Data is transmitted between the FocusMonitor FM+ and PC via the Ethernet connection.

Another device, such as a PowerMonitor PM 48/100, can be connected to the FocusMonitor FM+ via the RS485 interface (PRIMES bus). The signal from the PowerMonitor PM 48/100 is transmitted through the FocusMonitor FM+ to the PC via the Ethernet interface. The additional measuring device is powered by the power supply of the FocusMonitor FM+.

Please use only the provided connection lines.

Please ensure that all electrical connections have been established and switch the device on before starting the LaserDiagnosticsSoftware LDS.
The FocusMonitor FM+ serves as a dongle for the software on the computer in order to enable certain software functions.

8.1 Connections

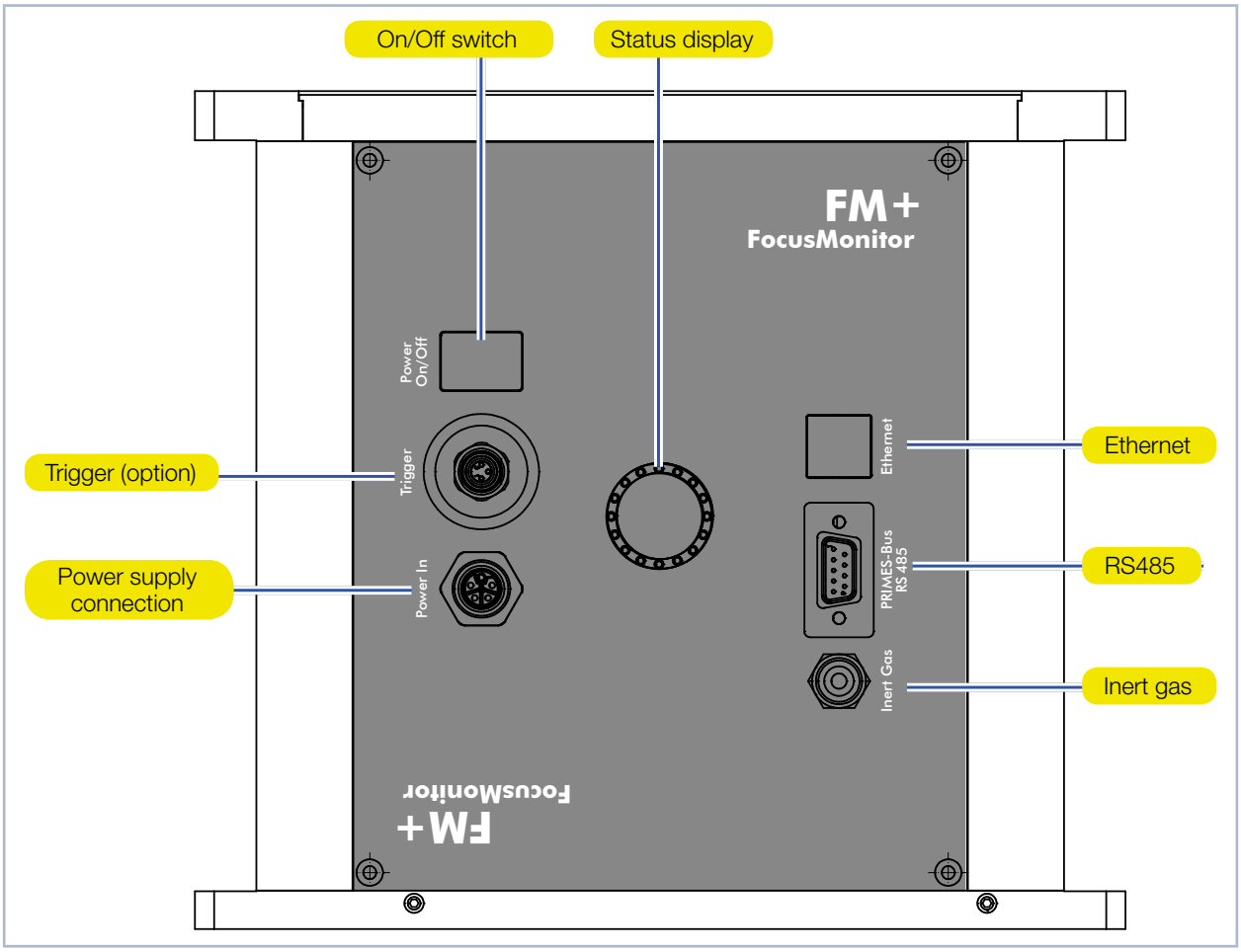
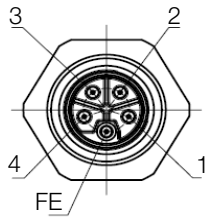


Fig. 8.1: FocusMonitor FM+ connections

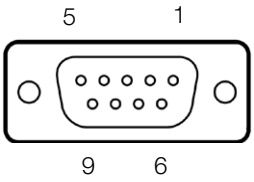
8.2 Pin assignment

8.2.1 Power supply

Harting M12-P-PCB-THR-2PC-5P-LCOD-M-STR		
	Pin	Function
	1	+24 V
	2	Not assigned
	3	GND
	4	Not assigned
	5	FE (functional earth)

Tab. 8.1: Connection socket for the power supply

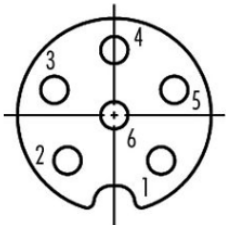
8.2.2 PRIMES bus RS485

Pin arrangement D-sub socket, 9-pin (view of plug-in side)		
	Pin	Function
	1	GND
	2	RS485 (+)
	3	+24 V
	4	Not assigned
	5	Not assigned
	6	GND
	7	RS485 (–)
	8	+24 V
	9	Not assigned

Tab. 8.2: D-sub socket, PRIMES bus

8.2.3 Trigger output (option)

As an option, the FocusMonitor FM+ can be delivered with a trigger output (3.3 V). The trigger signal is coupled with the rotation of the measuring tip and can thus be used for the synchronization of pulsed lasers.

Pin arrangement Binder M8 series 786/718, 6-pole (view from plug-in side)		
	Pin	Function
	1	Trigger +
	2	Trigger -
	3	Rotational pulse
	4	Not assigned
	5	Not assigned
	6	GND

Tab. 8.3: Trigger socket

8.3 Connection to the PC and establishing the power supply

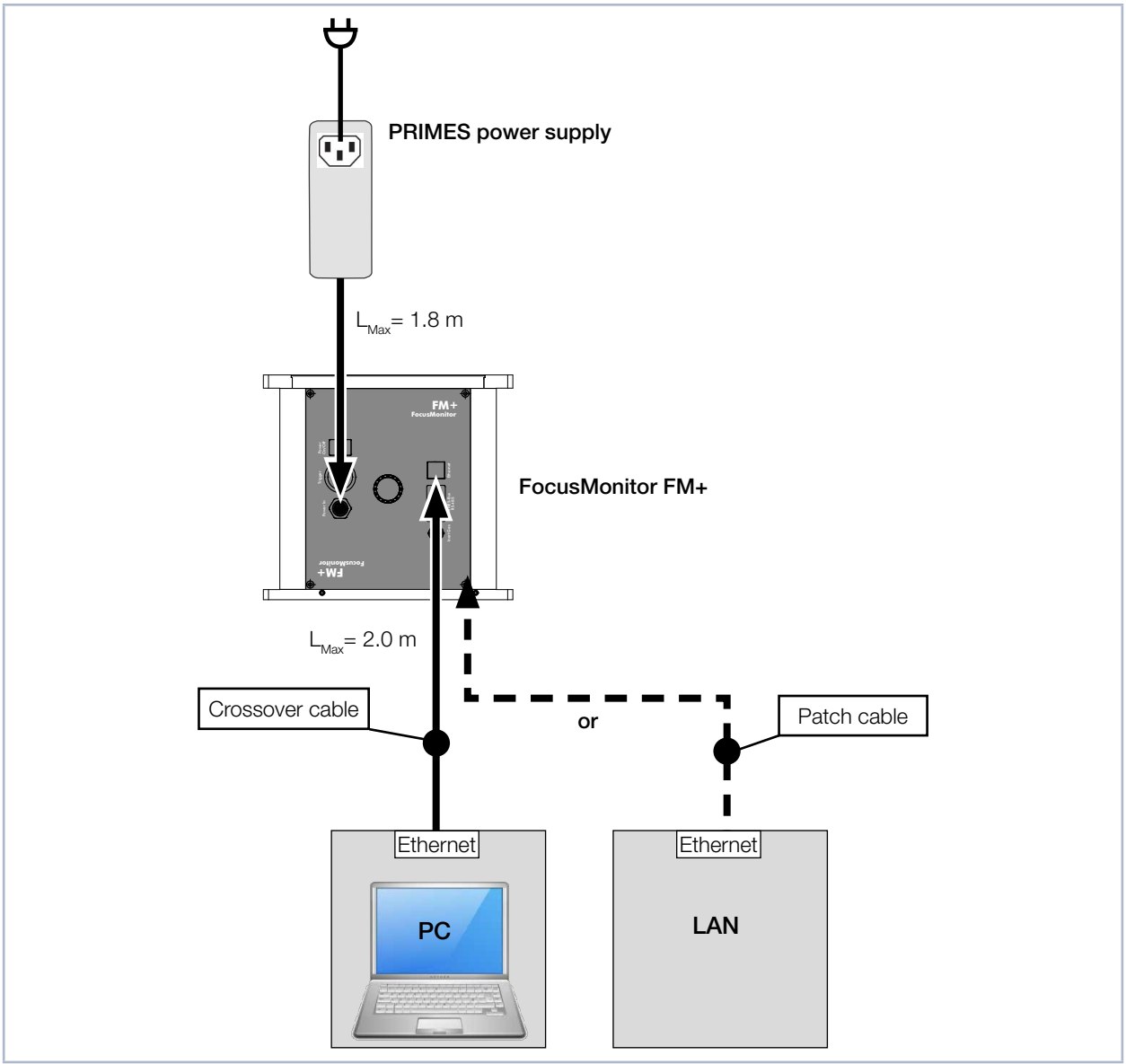


Fig. 8.2: Connection of FocusMonitor FM+

Connect the FocusMonitor FM+ to the PC via a crossover cable or to the network via a patch cable.

8.4 Connection of the FocusMonitor FM+ and PowerMonitor PM 48/100 to the PC

For full absorption of the radiation behind the measurement zone, you can use the PRIMES PowerMonitor PM 48/100. The water-cooled PowerMonitor PM 48/100 will show you the power, water flow rate, and water temperature.

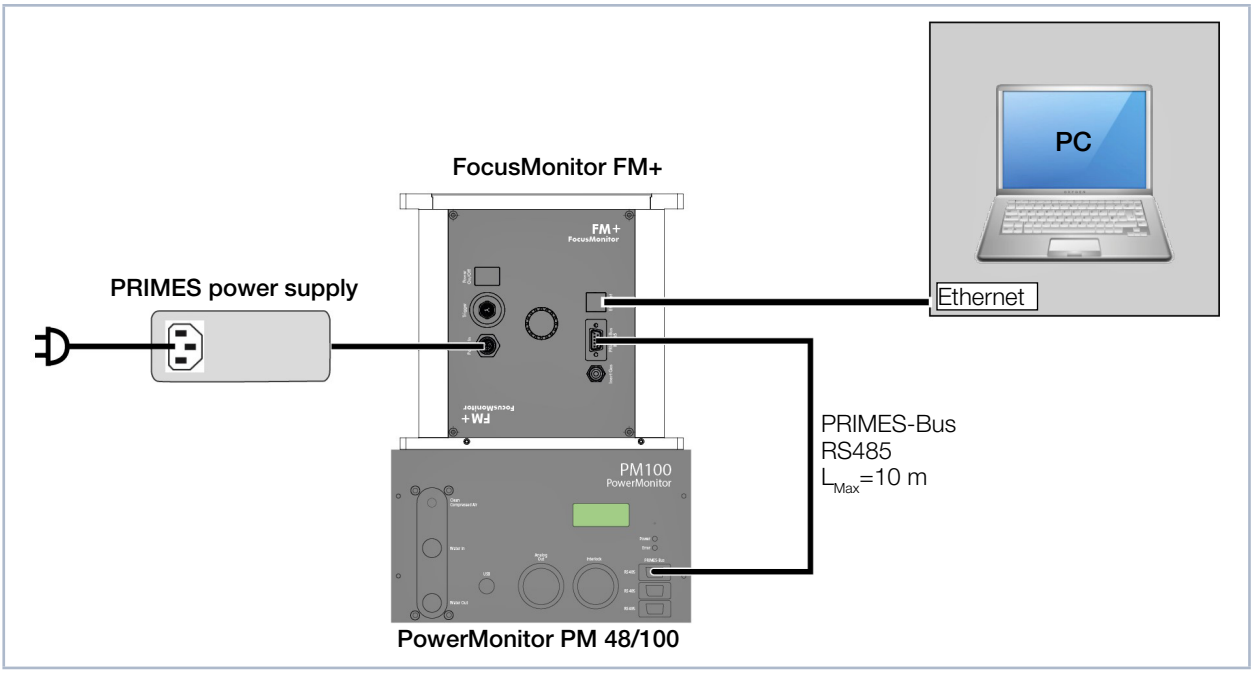


Fig. 8.3: Connection of the FocusMonitor FM+ and PowerMonitor PM 48/100 to the PC

NOTICE

Damage/Destruction of the device due to overvoltage

When disconnecting the electric cables during operation (when the supply voltage is connected), voltage peaks can be generated that could destroy the communication modules of the measuring devices.

▶ **Turn off the power supply before disconnecting the bus cables.**

Only ever use one power supply (typically original PRIMES power supply) when connecting several devices.

9 Inert gas connection

When measuring high power densities (CO_2 > 15 – 30 MW/cm²; NIR > 8 – 10MW/cm²), plasma may be ignited on the surface of the measuring tip. This could destroy the measuring tip (see chapter 18.3 on page 48 and chapter 18.4 on page 50). A suitable inert gas connection is therefore integrated into the devices (see Fig. 9.1 on page 25).

NOTICE

Damage/Destruction of the device

The effects of uncontrolled gas flow (e.g. process gas) could distort the measurement or even damage the device.

- ▶ **Only use helium, nitrogen or argon as the inert gas at the intended connection. The pressure may not exceed a maximum of 0.5 bar.**

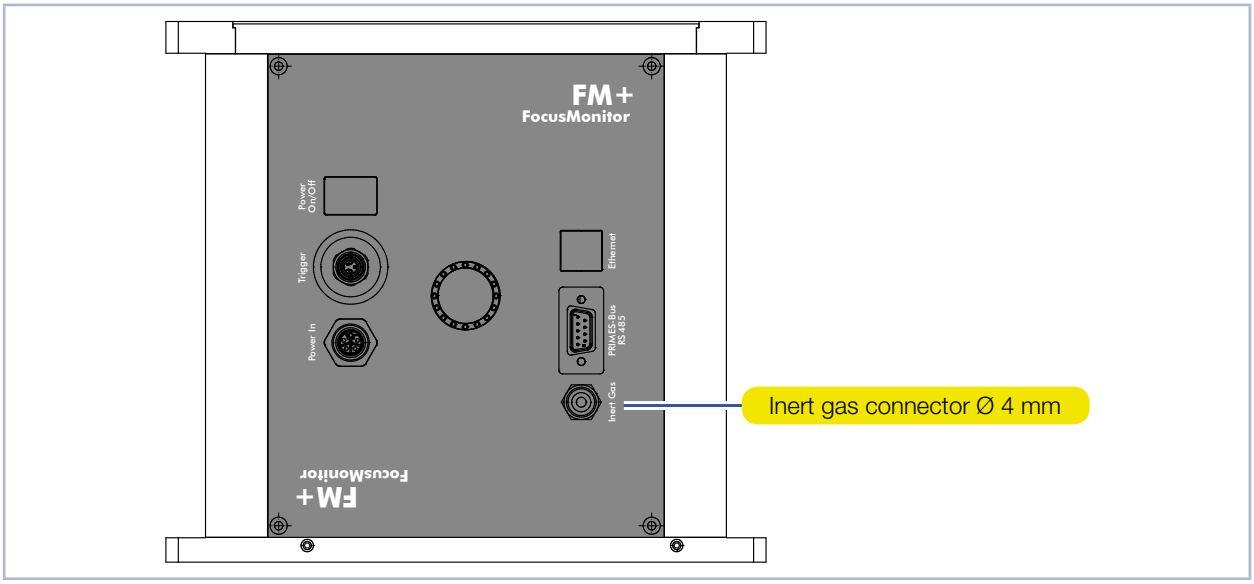
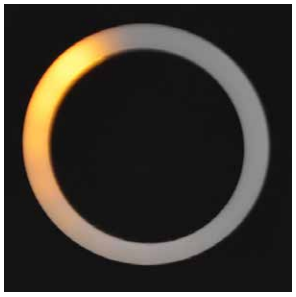


Fig. 9.1: Inert gas connection on the FocusMonitor FM+

10 Status display

The status display consists of a light ring that indicates different states of the FocusMonitor FM+ with different colors and static or rotating lights.



Color	Lighting state	Meaning
White	The entire ring illuminates	The supply voltage is connected
Yellow	Rotating light	The measuring tip rotates and the different rotational speeds are indicated.
Red	Rotating light	The measuring tip rotates and the y-axis is moved. The measurement is in progress, the different rotational speeds are indicated.

Tab. 10.1: States of the status display

11 Measuring

11.1 Safety instructions

DANGER

Serious eye or skin injury due to laser radiation

Depending on the measuring principle used, the laser beam is reflected at the measuring tip (laser class 4). The reflected beam is usually not visible.

- Please wear safety goggles (OD 6) adapted to the power, power density, laser wave length and operating mode of the laser beam source in use.
- Wear suitable protective clothing and protective gloves.
- Protect yourself from laser radiation by separating protective devices (e.g. by using appropriate shielding).
- In measurement mode, a safety distance of one meter to the FocusMonitor FM+ must be maintained even when wearing safety goggles and safety clothing.

DANGER

Serious eye or skin injury due to laser radiation

If the device is moved from its calibrated position, increased scattered or directed reflection of the laser beam occurs during measuring operation (laser class 4).

- Mount the device so that it cannot be moved by an unintentional knock or cables being pulled accidentally.

DANGER

Fire and explosion hazards due to scattered or directed laser radiation

When the FocusMonitor FM+ is being operated, the irradiation must be fully absorbed behind the measurement zone. Fire bricks or other partly-absorbing surfaces are not suitable.

- Use an adequate absorber. Dependent on the application, PRIMES offers suitable absorbers, such as the PowerMonitor PM 48/100.
- Don’t store any flammable materials or highly flammable substances at the measuring location.

CAUTION

Risk of injury caused by rotating parts

The measuring tip of the FocusMonitor FM+ rotates at high speed during the measuring operation. Even after the motor has been turned off, the measuring tip will continue to rotate for a certain amount of time.

- Do not reach into or hold any objects into the beam entrance of the measuring device.
- After the motor has been turned off, wait until the measuring tip comes to a complete stop (pay attention to the status display on the connection side).

⚠ CAUTION

Risk of crushing

Unlike the housing, the measuring head of the FocusMonitor FM+ can move along the z- and y-axis.

▶ **Do not reach into the movement range of the measuring head.**

11.2 Configure FocusMonitor FM+

1. Based on Tab. 18.1 on page 47, check whether the installed measuring tip is suitable for your measuring task. You will find instructions for switching out measuring tips in chapter 18.5 on page 52.

2. Based on Tab. 18.2 on page 47, check whether the installed detector is suitable for your measuring task. You will find instructions for switching out detectors in chapter 18.6 on page 54.

3. Determine the necessary revolution speed of the measuring tip, taking into account the permissible power density based on Tab. 18.4 on page 49 or Tab. 18.6 on page 51.

NOTICE

Damage/Destruction of the measuring tip

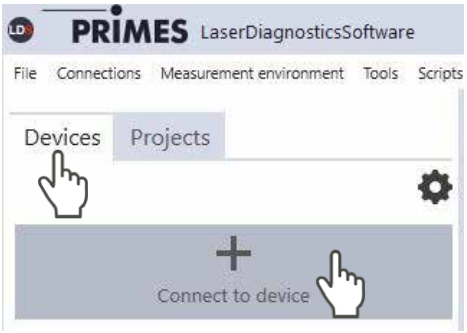
In case of very high power densities (CO_2 > 15 – 30 MW/cm²; NIR > 8 – 10 MW/cm²), plasma may be ignited on the surface of the measuring tip. This could destroy the measuring tip.

▶ **Increase the speed according to the Tab. 18.4 on page 49 or Tab. 18.6 on page 51 and purge it with inert gas, if necessary.**

11.3 Connect the FocusMonitor FM+ with the LaserDiagnosticsSoftware LDS

11.3.1 Connect device

1. Switch on the FocusMonitor FM+.
   The operating mode is shown in the status display (see chapter 10 on page 25).
2. Start the LaserDiagnosticsSoftware LDS.
3. Click on the ***Devices*** tab.
4. Click on the ***+ Connect to device*** button under the tab.



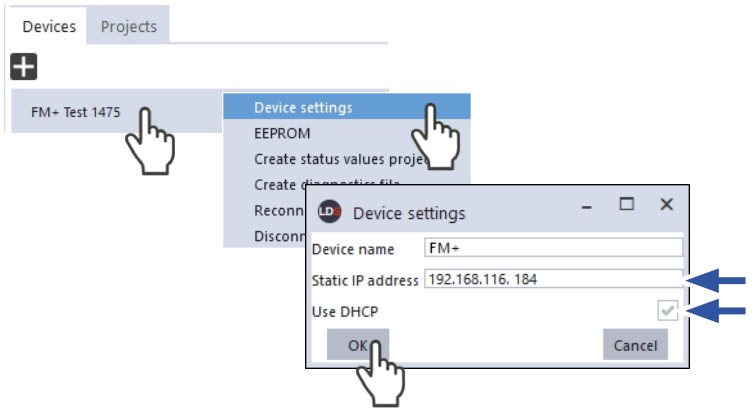
The ***Connections*** window appears.

5. Click on the desired device.
6. Click on the ***Connect to device*** button.

11.3.2 Change the network address of a connected device

Proceed as follows in order to assign a different IP address to a connected device:

1. Right-click on the device and select the ***Device settings*** menu point.
2. Enter in the desired IP address or use the ***Use DHCP*** option and confirm the entry with ***OK***.
3. Turn the FocusMonitor FM+ off and on again.



11.4 Performing an automatic caustic measurement

This chapter aims to provide some basic information as you get to know the FocusMonitor FM+, discussing the example of an automatic caustic measurement with the LaserDiagnosticsSoftware LDS.
For a detailed description of the software installation, file management and evaluation of the measured data, please refer to the separate operating manual LaserDiagnosticsSoftware LDS.

11.4.1 Selecting the measuring mode automatic caustic

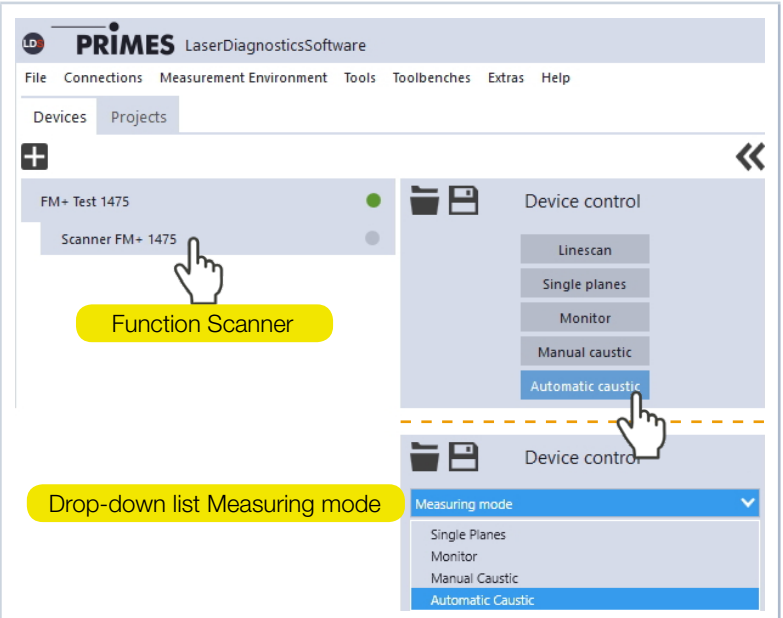
1. Connect the device according to chapter 11.3 on page 28 with the LaserDiagnosticsSoftware LDS.

The FocusMonitor FM+ is established as a connected device.

2. Click on the ***Scanner*** function.

The ***Device control*** menu opens.

3. Click on the ***Automatic caustic*** button or on the drop-down list measurement mode and ***Automatic caustic***.



The corresponding ***Device control*** opens.

The ***Automatic caustic*** tool bench opens with the following tools:

- ***Caustic analysis***
- ***Plane analysis***

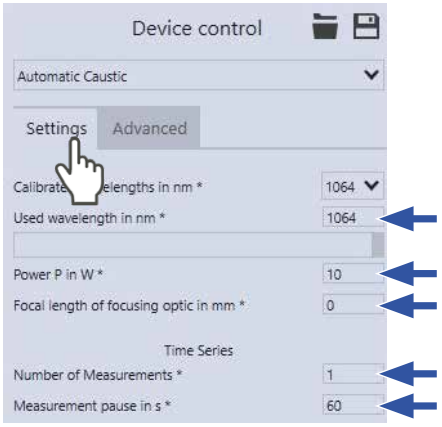
11.4.2 Configuring the settings (*Device control* > *Settings*)

1. Click on the ***Settings*** tab.

2. Enter the laser wavelength used in nm.
3. Enter the laser output in W.
4. Enter the focal length of the focusing lens in mm.

Only when measuring a time series

5. Enter the number of automatic caustic measurements.
6. Enter the measuring break between automatic caustic measurements in s.



11.4.3 Configuring advanced settings (*Device control* > *Advanced*)

1. Click on the ***Advanced*** tab.
2. Enter the number of pixels in the x/y-direction in order to configure the resolution on the CCD sensor.
3. Enter the number of planes. Specifying 21 planes already generates a valid measurement.
4. Enter in the rotation speed of the measuring tip 1875, 3750, 7500 min^{-1}.

Locked area

▶ Define a locked area when there are obstacles in the measuring area.

- More detailed information on locked areas can be found in chapter 11.4.4 on page 32.

Move axes

▶ To align the device (see Fig. 7.6 on page 18) or to initiate a measurement at this position, enter 60 mm for the z-position.

- The vertical carriermoves to the specified position.
- More detailed information on traversing the axes can be found in chapter 11.4.5 on page 33.

Measuring tip

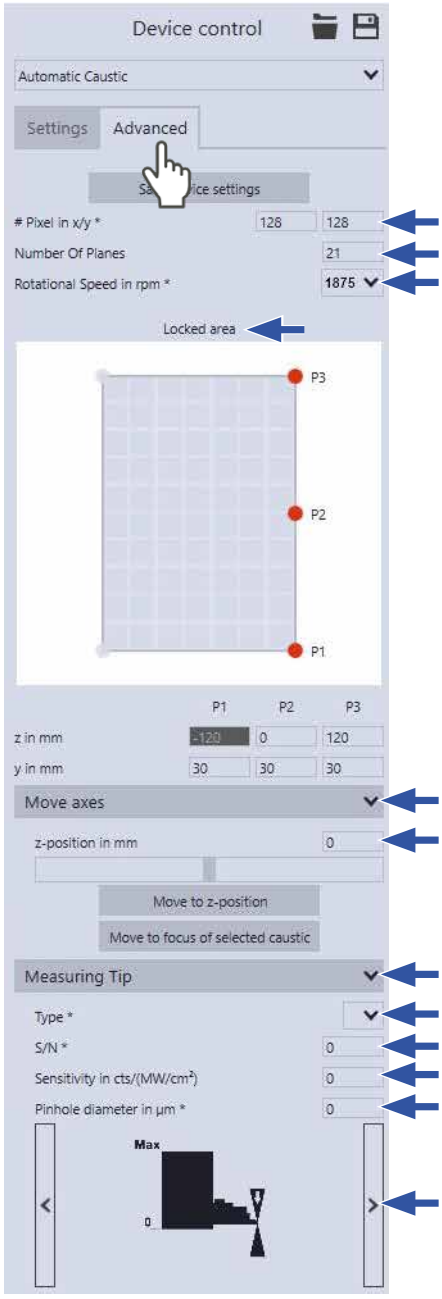
You will find the entry values on the label attached to the packaging of the measuring tip used.

5. Choose the type of measuring tip used.
6. Enter the serial number S/N of the measuring tip.
7. Enter the sensitivity of the measuring tip used in cts/(MW/cm²).
8. Enter the pinhole diameter of the measuring tip used.

Rotated measuring tip

▶ Click on one of the **< >** buttons if you are using the FocusMonitor FM+ mounted upside down with a rotated measuring tip.
The top of the measuring tip always has to be facing the incident laser beam.

- More detailed information on a rotated measuring tip can be found in chapter 11.4.6 on page 34.



11.4.4 Defining the locked area (*Device control* > *Advanced* > *Locked area*)

A locked area is a spacial limitation of the measurement area in the y- and z-direction ensuring that, for example, the measurement tip moves around any obstacles in this area.

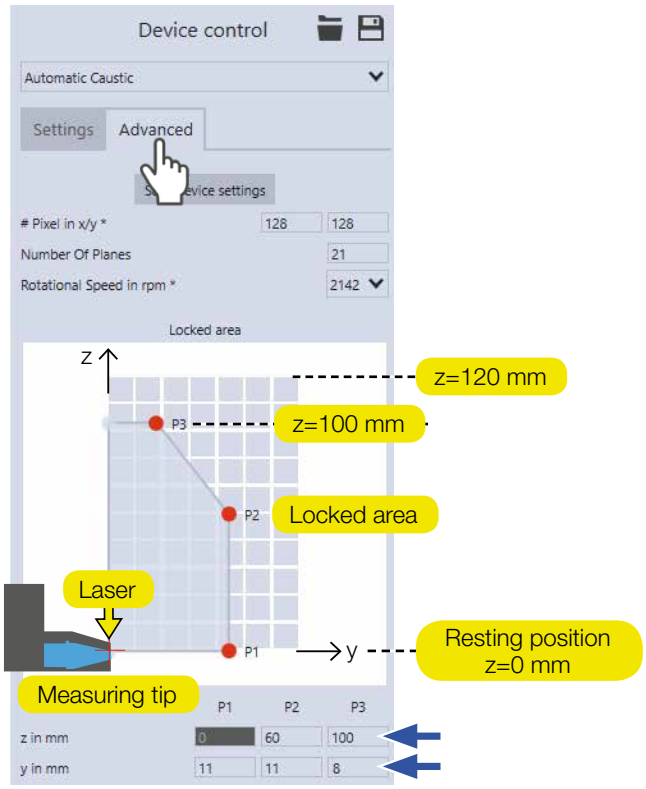
For standard installation
The origin of the locked area is defined by the opening in the measuring tip (pinhole). The position z=0 and y=0 defines the the lower left corner of the locked area.

- ▶ Pull the mouse button to three points P1, P2, P3 to define the locked area.
- As an alternative, you can numerically enter the locked area in the entry fields below.

Example
In the figure, the locked area is set to z=100 mm for the z-axis in Point P3.

- This causes the device's vertical carrier to move in the z-direction from z=0 mm to z=100 mm.

The z-coordinate of the point P1 is already defined by the resting position of the measuring tip and cannot be changed.

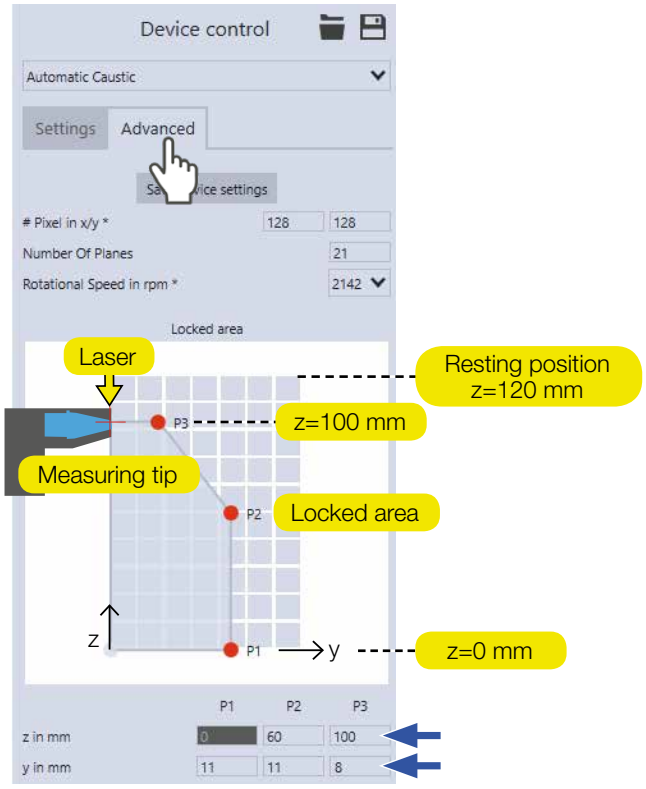


For upside down installation with rotated measuring tip
The origin of the locked area is defined by the opening in the measuring tip (pinhole). The position z=120 and y=0 defines the the top left corner of the locked area.

Example
In the figure, the locked area is set to 100 mm for the z-axis in Point P3.
This causes the device's vertical carrier to move in the z-position from z=0 mm to z=100 mm.

Device must be in the resting position before it can be stored in the transport box
Since the locked area is saved in the device, it will no longer be possible to move to the resting position in the position z=120.

- ▶ Reset the locked area before turning off the device.



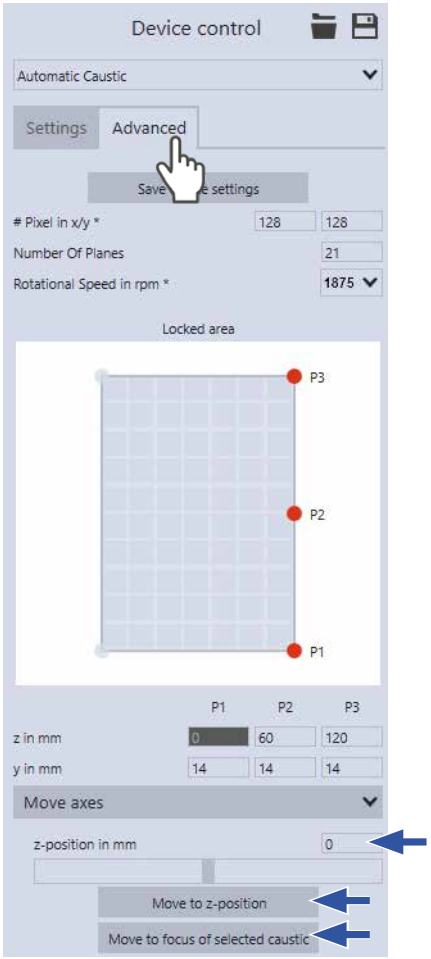
11.4.5 Traversing the axes (*Device control* > *Advanced* > *Move axes*)

1. Enter the desired z-position of the measuring tip into the entry field numerically.
- As an alternative, you can set the z-position on the slide control.

2. Click on the ***Move to z-position button.***
- The measurement tip is positioned at the selected position.

Move to the determined focus
You can also move to the determined focus of a caustic that has already been recorded if, for example, you want to measure a similar beam. During this process, the z_0 value of the ***Invariant moments*** algorithm is used:

1. Choose a caustic for this in the project tree (see separate operating manual of the LaserDiagnosticsSoftware LDS).
2. Then click on the ***Move to focus of selected caustic*** button.



11.4.6 Rotated measuring tip (*Device control* > *Advanced* > *Measuring tip*)

When necessary, you can turn the measuring tip or the entire device by 180 degrees and measure in this position. If you rotate the measurement tip of the FocusMonitor FM+, to carry out a measurement “upside down” for example, you will have to configure and save this in ***Device control* > *Advanced***.

1. Click on one of the **< >** buttons next to the figure showing the FocusMonitor FM+

👁 The figure is rotated 180 degrees.

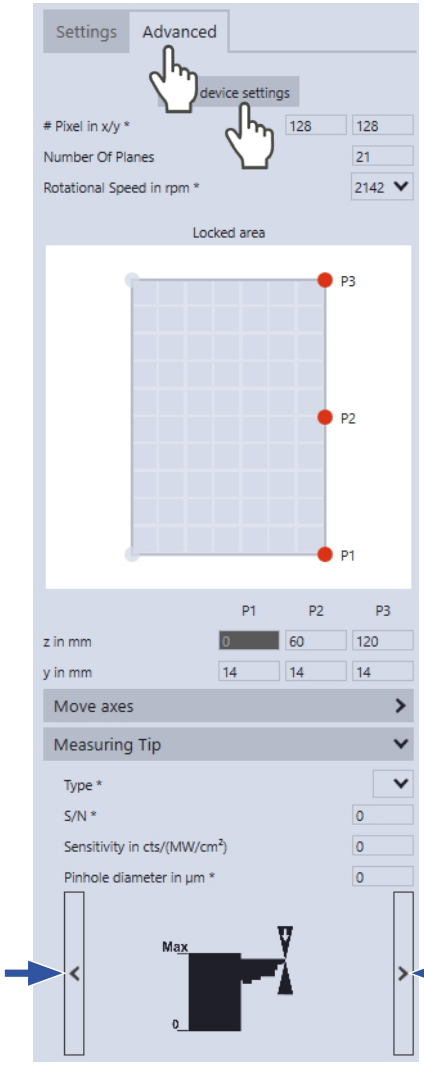
2. Click on ***Save device parameters***.

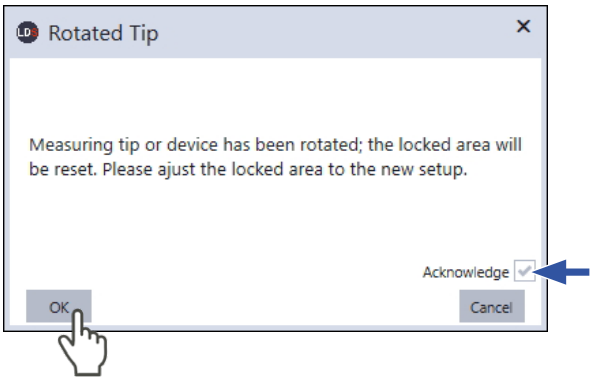
👁 The confirmation window will appear. You will receive notification that the locked area, if defined, must be adjusted.

3. Check the checkbox next to ***Acknowledge*** and click on ***OK***.

- The locked area is reset.
- The measuring tip is saved in the device in its rotated state
- The rotated measuring tip is applied to all measuring modes.

4. Adapt the locked area to the rotated measuring tip as described in chapter 11.4.4 on page 32.

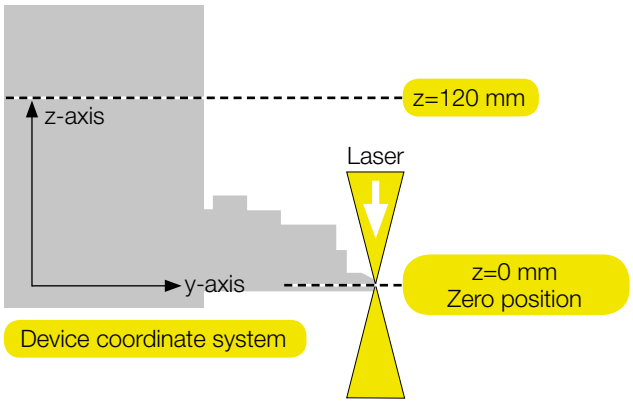




11.4.7 Coordinate system for measurements with rotated measuring tip

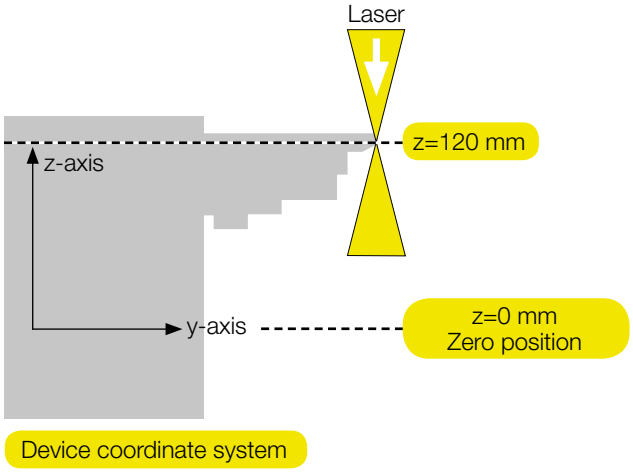
The coordinates given as the z-position when measuring always relate to the device coordinate system, which changes when the device or measurement tip is rotated.

For standard installation
The figure shows the device in its resting position.



For upside down installation with rotated measuring tip
The figure shows the device in its resting position.

If the device is operated in its rotated position and the ***Measuring tip rotated*** option has been selected, the orientation of the z-axis is rotated.



11.4.8 Starting an automatic caustic measurement

1. Follow the safety instructions in chapter 11.1 on page 26.
2. Turn on the laser.

3. Click on the ***Start*** button.

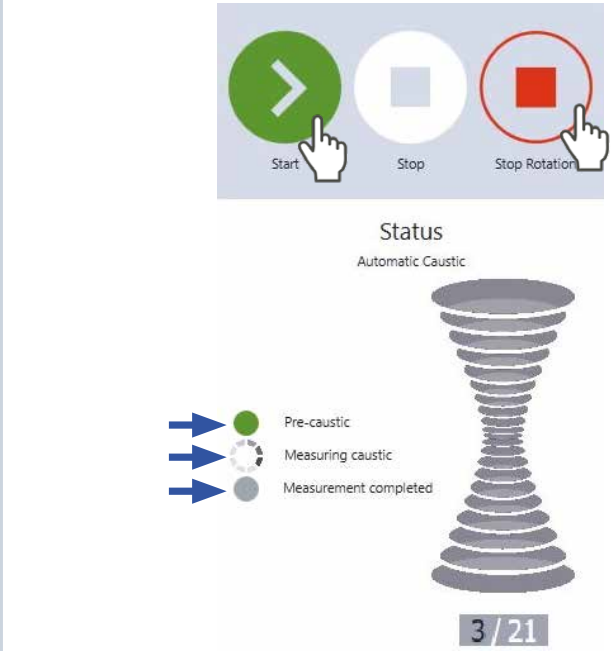
The progress of the measurement is indicated when ***Pre-caustic***, ***Measuring caustic*** and then ***Measuring completed*** are displayed:

Pre-caustic
As the indication is being displayed, the optimal measuring parameters such as measuring window position, measuring window size, integration time, and the z-range (measuring range along the beam propagation) are determined automatically.

Measuring caustic
The actual measurement is carried out during the indication.

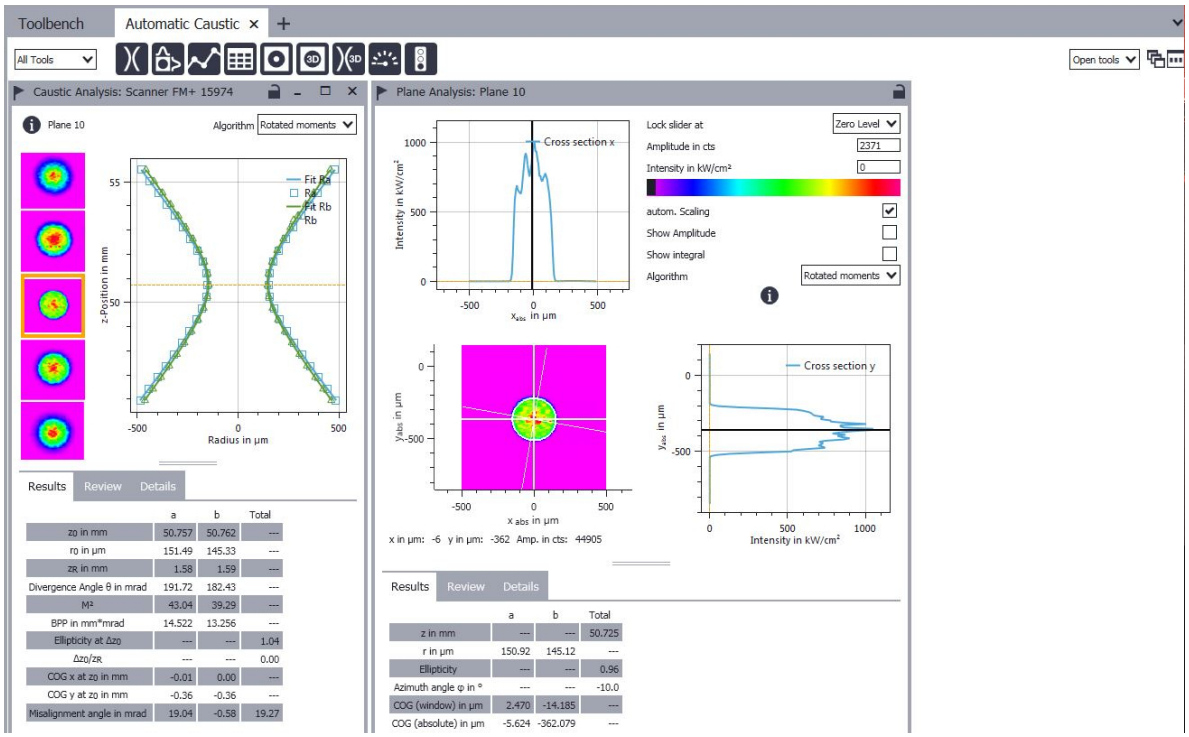
Measuring completed
The measurement has been completed.

4. Turn off the laser.
5. Press the ***Stop Rotation*** button to stop the rotation of the measuring tip.



11.4.9 Measuring results display

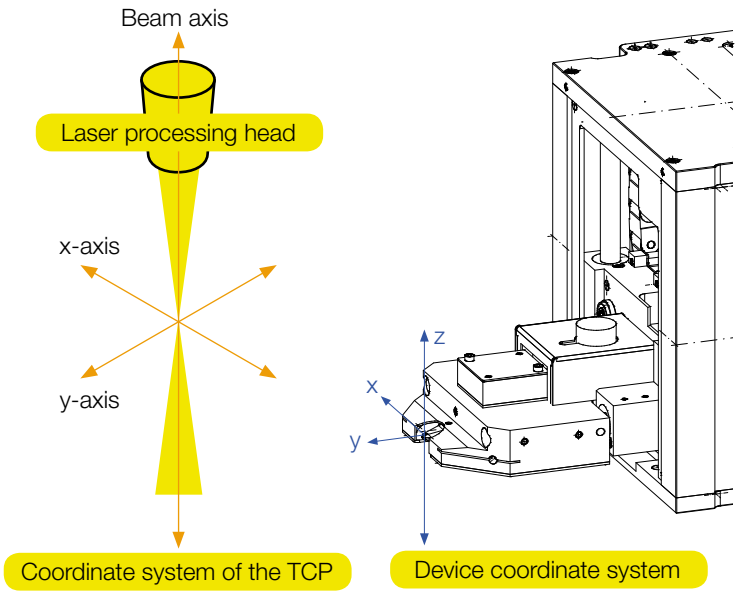
The measuring results are displayed in the opened tools once the measurement has been completed (see below). A detailed description of the tools and the assessment of the measuring results can be found in the separate operating manual for the LaserDiagnosticsSoftware LDS.



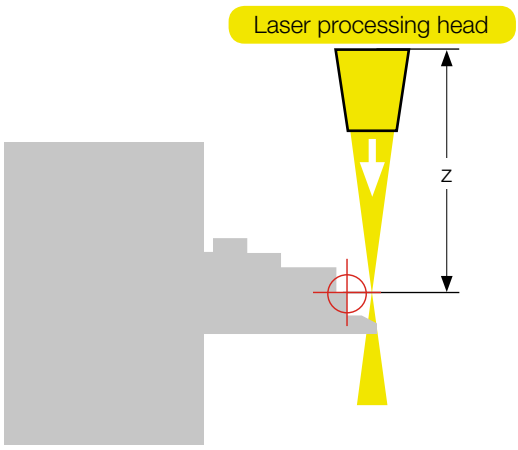
11.5 Determining the tool center point (TCP) using the FocusMonitor FM+

The tool center point (TCP) is usually located on the beam axis on the focus plane.

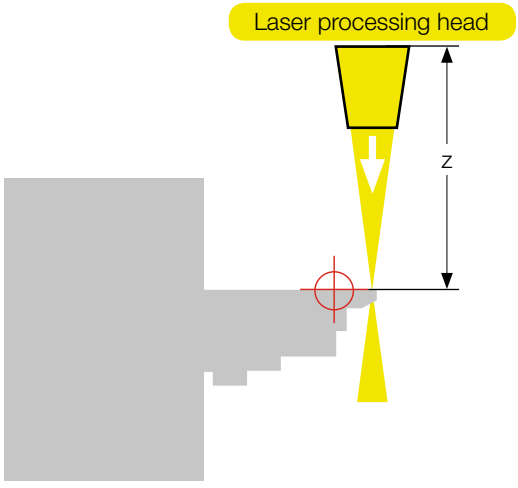
1. Set up the FocusMonitor FM+ as described in chapter 7.4 on page 18.
2. Install the FocusMonitor FM+ as described in chapter 7.5 on page 20.
3. Perform an automatic caustic measurement as described in chapter 11.4 on page 29.
4. Move the measuring carrier of the FocusMonitor FM+ to the determined focus plane as described in chapter 11.4.5 on page 33.
   - The FocusMonitor FM+ moves the reference plane to the focus position (see figures in chapter 11.5.1 on page 39).



5. Measure the Distance z between the reference plane of the horizontal carrier (see figure in chapter 11.5.1 on page 39) and the reference plane on the laser processing head.
6. Position the laser processing head at distance z above the workpiece.
   - Here z is the distance from the reference plane at the laser processing head to the workpiece surface.
7. Specify a short laser pulse with low output on the workpiece.
8. Align the reticle of the coaxial observation camera with the penetration (x, y-position).
9. Use the reticle to align the laser processing head with a known fixed point in the machine coordinate system.
10. Set the correct working distances between the laser processing head and the previously selected fixed point.
11. Apply the axis values for this position.
    - The tool center point (TCP) has been determined.



Standard installation



Upside down installation with turned measuring tip

11.5.1 Position of the aperture in the measuring tip (pinhole) in relation to the horizontal carrier

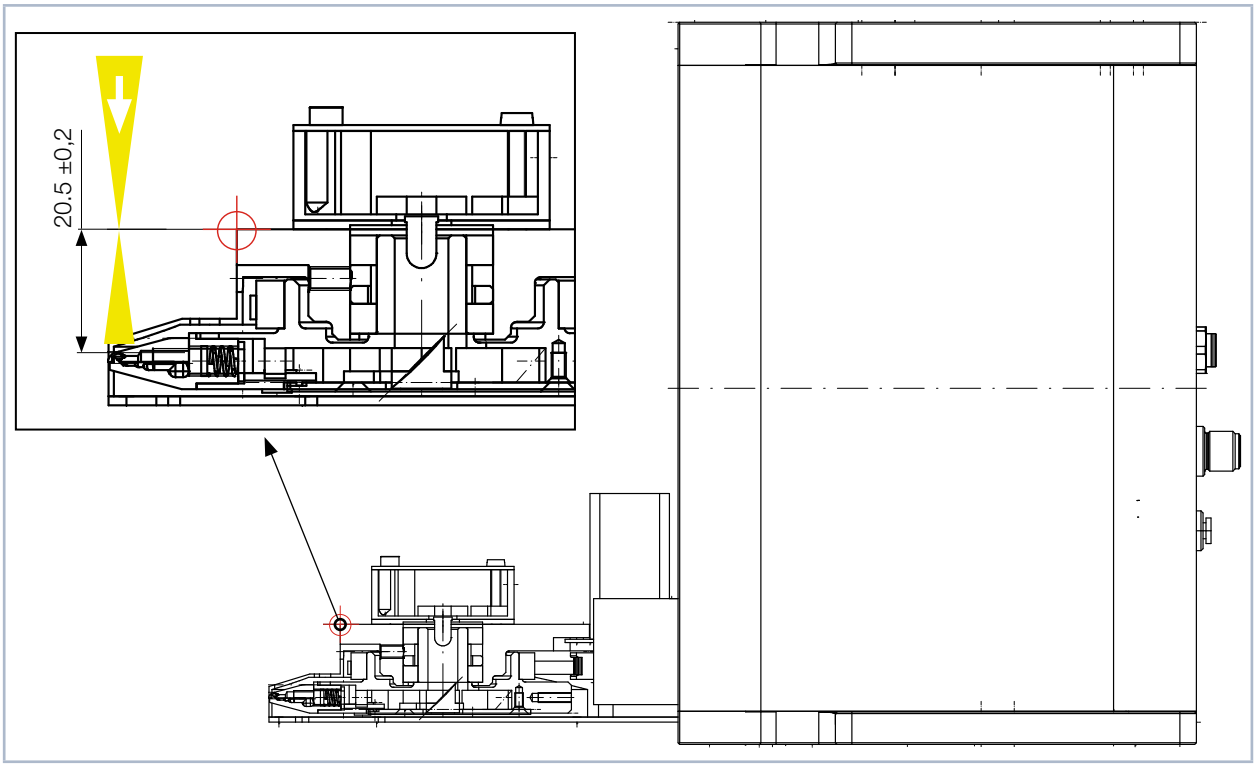


Fig. 11.1: Distance from the aperture in the measuring tip (pinhole) to the reference plane of the horizontal carrier

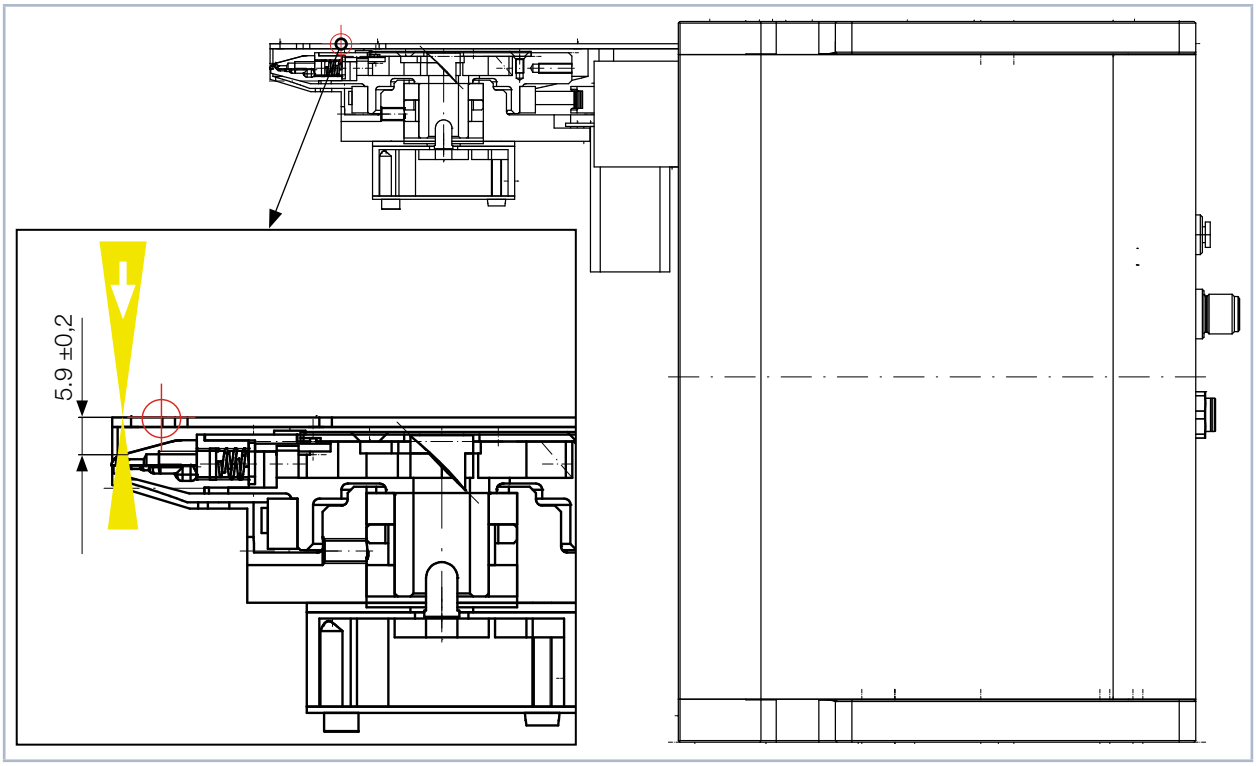


Fig. 11.2: Distance from the aperture in the measuring tip (pinhole) to the reference plane on the bottom of the horizontal carrier

12 Troubleshooting

Error	Possible cause	Remedy
Error during a measurement	• Data transmission error • Processor crash in the measuring system • Program execution error	1. Restart the software. 2. Turn off the supply voltage, turn it on again, and start another reset cycle. 3. Restart the computer.
Apart from the ambient noise and zero offset, no measuring signal is available.	The device is not aligned correctly.	Check the device alignment to the laser beam.
	The power density in the focus is too low.	Increase the laser power. The absolute power density in the focus typically has to be several hundred kW/cm² to achieve a significant measuring signal with a standard measuring tip.
	The selected resolution is too low for smaller focus spots (e.g. r_f= 80 µm) and a maximum measuring window.	First measure outside the direct focus area. If this does not lead to a result, increase the resolution (e.g. 256 x 256).
	The measuring tip is defective.	Insert a new measuring tip (also see chapter 18.5 on page 52).
	The measuring tip is installed incorrectly.	Turn the measuring tip around.
	The signal enhancement is too low.	Set the maximum enhancement and select the maximum measuring range.
The measuring tip is destroyed during the measurement.	The power density is too high, igniting plasma on the surface of the measuring tip.	Increase the speed of the measuring tip (see Tab. 18.4 on page 49 and Tab. 18.6 on page 51) and purge the measuring area with inert gas.
When measuring small beams, an offset of the recorded measuring tracks to one another is observed.	Fluctuations in the synchronism of the rotation disc and delays in triggering the trigger signal.	Position the beam as close to the left edge of the window as possible. The time interval between the trigger signal and start of the measurement is then smaller and errors can thus be reduced. Averaging is also often helpful in this case.

13 Maintenance and service

The operator is responsible for determining the maintenance intervals for the measuring device.
PRIMES recommends a maintenance interval of 12 months for inspection and validation or calibration.
If the device is used only sporadically, the maintenance interval can also be extended up to 24 months.

14 Product disposal measures

In accordance with the Electrical and Electronic Equipment Act (Elektro-G), PRIMES is obliged to dispose of PRIMES measuring devices manufactured after August 2005 free of charge.
PRIMES is registered in the German Used Appliance Register (Elektro-Altgeräte-Register (EAR)) as a manufacturer with the number WEEE reg. no. DE65549202.
Within the EU, you are welcome to send your PRIMES measuring devices to the following address to dispose of them free of charge:

PRIMES GmbH
Max-Planck-Str. 2
64319 Pfungstadt
Germany

15 Declaration of conformity

Original EG Declaration of Conformity

The manufacturer: PRIMES GmbH, Max-Planck-Straße 2, 64319 Pfungstadt, Germany,

hereby declares that the device with the designation:

FocusMonitor (FM)

Types: FM35; FM120; FM+ 120; FMW; FMW+

is in conformity with the following relevant EC Directives:

- Machinery Directive 2006/42/EC
- EMC Directive EMC 2014/30/EU
- Low voltage Directive 2014/35/EU
- Directive 2011/65/EC on the restriction of the use of certain hazardous substances (RoHS) in electrical and electronic equipment
- Directive 2004/22/EC on measuring instruments

Authorized for the documentation:
PRIMES GmbH, Max-Planck-Straße 2, 64319 Pfungstadt, Germany

The manufacturer obligates himself to provide the national authority in charge with technical documents in response to a duly substantiated request within an adequate period of time.

Pfungstadt, April 26, 2017

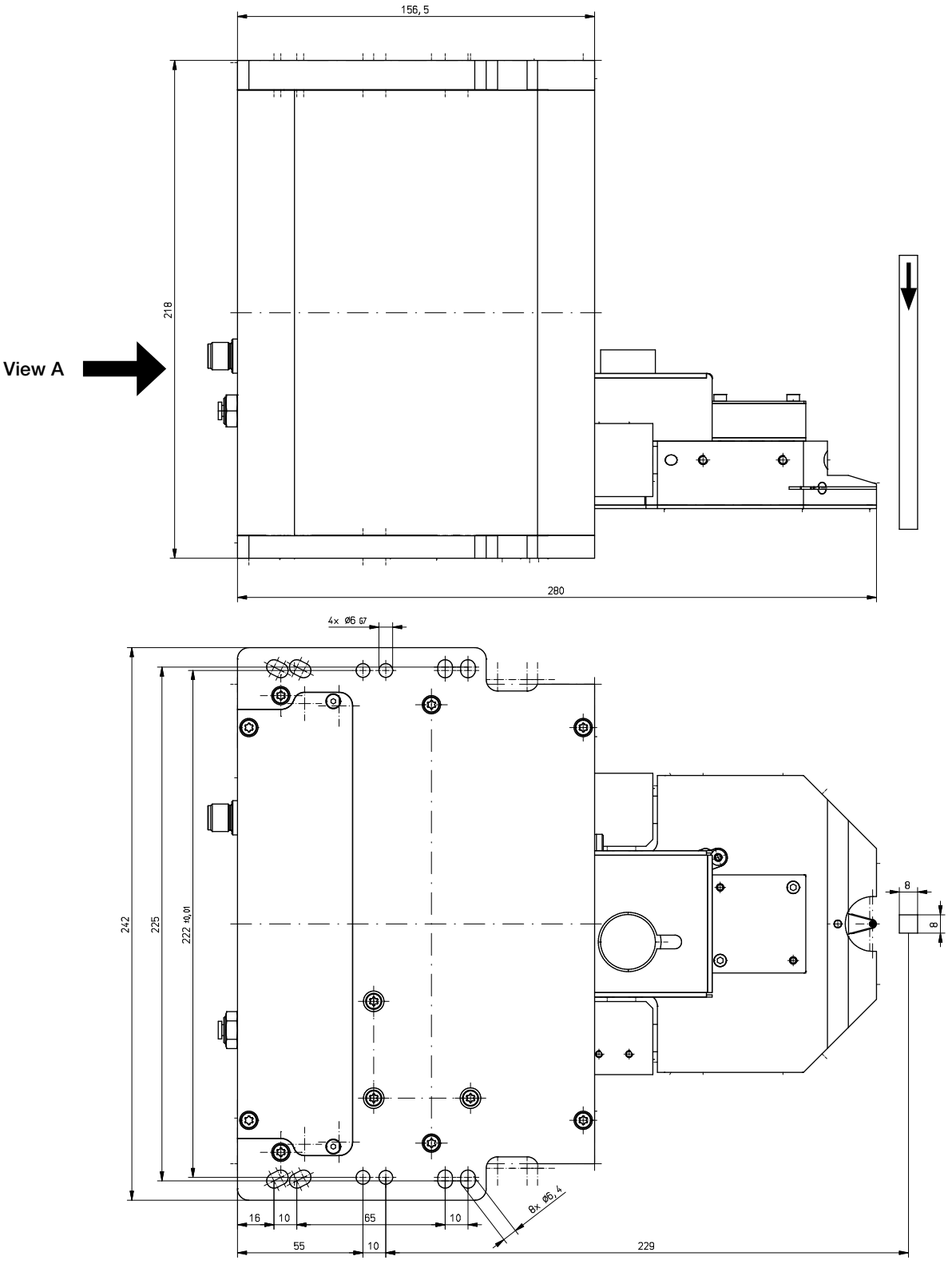
Dr. Reinhard Kramer, CEO

16 Technical data

Measurement parameters		
Power range		30 – 25 000 W
Wavelength range		0.4 – 12 µm
Beam dimensions		100 – 3 000 µm (up to 5 000 µm optional)
Max. power density range CO_2 and NIR laser		See Tab. 18.4 on page 49 and Tab. 18.6 on page 51
Max. Power density at different measuring tips	CO_2 laser (10 600 nm)	30 MW/cm²
	Nd:YAG laser (1 000 – 1 100 nm)	10 MW/cm²
	VIS laser (515 – 550 nm)	5 MW/cm²
	Diode laser (400 – 1 000 nm)	1 MW/cm²
Determined parameters		
Focus position x, y, z		yes
Focus radius x, y		yes
Beam quality factor M²		yes
Raw beam diameter with focussing element		yes
Beam parameter product BPP		yes
Divergence angle		yes
Power density distribution		2D, 3D
Device parameters		
Working range x-y		8 x 8 mm (12 x 12 mm or 24 x 12 mm optional)
Working range z		120 mm
Measurement window sizes		0.1 x 0.1 – 8 x 8 mm (resolution 64 pixel)
Resolution		32 x 32 – 1024 x 1024 pixel
Rotation speed of the measuring tip		1875, 3750, 7500 rpm
Line focus		yes
Linescan		optional
Supply data		
Power supply		24 V DC ± 5 %, max. 3.5 A
Inert gas (water and oil free)		Helium, Nitrogen or Argon
Pressure protective gas		typ. 0.5 bar
Communication		
Interfaces		RS485/Ethernet
Trigger-delay port		optional

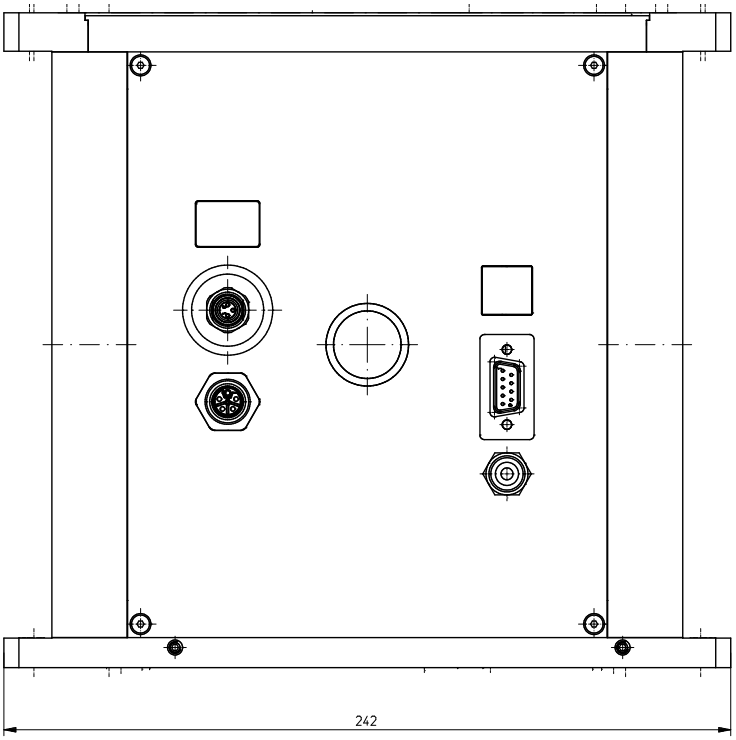
Dimensions and weight	
Dimensions (L x W x H)	280 x 242 x 218 mm
Weight (approx.)	8.5 kg
Environmental conditions	
Operating temperature range	10 – 40 °C
Storage temperature range	5 – 50 °C
Reference temperature	22 °C
Permissible relative humidity (non-condensing)	10 – 80 %

17 Dimensions



All dimensions in mm (general tolerance ISO 2768-v)

View A



All dimensions in mm (general tolerance ISO 2768-v)

18 Appendix

18.1 System control (option)

An optional connection to the system control is available. Please contact your PRIMES sales partner with any questions.

18.2 Variety of detectors and measuring tips

Different measuring tips and detectors are available for different wavelengths, power density ranges, or beam divergences so that measurements can be recorded at a maximum power in each case. This ensures that an optimum configuration of the FocusMonitor FM+ is achieved. Only one value can be exploited fully for the power or power density.

Measuring tips	CO_2 high power	NIR high div	Diode
Typical pinhole diameter in µm	20 – 25	20	50
Beam divergence/acceptance angle in mrad	< 240	< 200	< 500
Typical wavelength in µm	9 – 12	0.4 – 1.7	0.4 – 1.7
CO_2 laser			
Max. power density *) in MW/cm²	30	—	—
Max. power in kW	15	—	—
Nd: YAG laser			
Max. power density *) in MW/cm²	—	10	1
Max. power in kW	—	10	4
VIS laser			
Max. power density *) in MW/cm²	—	5	—
Max. power in kW	—	5	—
Diode laser			
Max. power density in MW/cm² *)	—	2	1
Max. power in kW	—	6	4
Suitable detectors			
Detector types	DFC+	DFIG-PS+, DFY-PS+	DFIG-PS+, DFY-PS+

Tab. 18.1: Variety of measuring tips and detectors

*) Please note the damage threshold in Tab. 18.4 on page 49 and Tab. 18.6 on page 51.

Depending on the model, the measuring tips are suitable for different power densities. The power density is dependent on the laser power and focus size.

Different detectors are used, depending on the application:

Detector type	Laser	Type of sensor	Amplification	Wavelength range in µm
DFC+	CO_2	Pyroelectric detector	1	9 – 12
DFY-PS+	NIR/VIS	Photodiode	Automatic adjustment of the sensitivity	0.4 – 1.1
DFIG-PS+	NIR	Photodiode	Automatic adjustment of the sensitivity x	0.9 – 1.7

Tab. 18.2: Variety of detectors

18.3 Limit values for measuring operation with CO_2 high power measuring tip

Measuring tips can be operated up to the following maximum power densities:

Power	Maximum power density
Up to 6 kW	30 MW/cm²
6 kW bis 12 kW	20 MW/cm²
Up to 20 kW	15 MW/cm²

Tab. 18.3: Power and maximum power density

The calculations assume a Gaussian profile.

The maximum power density in real beams with the same dimensions is often slightly smaller (typically minus 10 – 20%, minus 50% for a tophat distribution). In case of doubt, start with a lower laser power.

Arrangement in the table

Table element	White	Green	Yellow	Orange	White with red values
Speed in rpm	1875	3750	7500	7500 with inert gas purging	**Risk of destruction!**

Focus diameter in µm	Power in kW									
	0.10	0.50	1.00	1.50	2.00	4.00	6.00	8.00	12.00	20.00
70	5.20	25.98	51.97	77.95	103.94	207.88	311.81	415.75	623.63	1039.38
80	3.98	19.89	39.79	59.68	79.58	159.15	238.73	318.31	477.46	795.77
90	3.14	15.72	31.44	47.16	62.88	125.75	188.63	251.50	377.26	628.76
100	2.55	12.73	25.46	38.20	50.93	101.86	152.79	203.72	305.58	509.30
125	1.63	8.15	16.30	24.45	32.59	65.19	97.78	130.38	195.57	325.95
150	1.13	5.66	11.32	16.98	22.64	45.27	67.91	90.54	135.81	226.35
175	0.83	4.16	8.32	12.47	16.63	33.26	49.89	66.52	99.78	166.30
200	0.64	3.18	6.37	9.55	12.73	25.46	38.20	50.93	76.39	127.32
225	0.50	2.52	5.03	7.55	10.06	20.12	30.18	40.24	60.36	100.60
250	0.41	2.04	4.07	6.11	8.15	16.30	24.45	32.59	48.89	81.49
275	0.34	1.68	3.37	5.05	6.73	13.47	20.20	26.94	40.41	67.34
300	0.28	1.41	2.83	4.24	5.66	11.32	16.98	22.64	33.95	56.59
325	0.24	1.21	2.41	3.62	4.82	9.64	14.47	19.29	28.93	48.22
350	0.21	1.04	2.08	3.12	4.16	8.32	12.47	16.63	24.95	41.58
375	0.18	0.91	1.81	2.72	3.62	7.24	10.86	14.49	21.73	36.22
400	0.16	0.80	1.59	2.39	3.18	6.37	9.55	12.73	19.10	31.83
425	0.14	0.70	1.41	2.11	2.82	5.64	8.46	11.28	16.92	28.20
450	0.13	0.63	1.26	1.89	2.52	5.03	7.55	10.06	15.09	25.15
475	0.11	0.56	1.13	1.69	2.26	4.51	6.77	9.03	13.54	22.57
500	0.10	0.51	1.02	1.53	2.04	4.07	6.11	8.15	12.22	20.37
525	0.09	0.46	0.92	1.39	1.85	3.70	5.54	7.39	11.09	18.48
550	0.08	0.42	0.84	1.26	1.68	3.37	5.05	6.73	10.10	16.84
575	0.08	0.39	0.77	1.16	1.54	3.08	4.62	6.16	9.24	15.40
600	0.07	0.35	0.71	1.06	1.41	2.83	4.24	5.66	8.49	14.15
625	0.07	0.33	0.65	0.98	1.30	2.61	3.91	5.22	7.82	13.04
650	0.06	0.30	0.60	0.90	1.21	2.41	3.62	4.82	7.23	12.05
675	0.06	0.28	0.56	0.84	1.12	2.24	3.35	4.47	6.71	11.18
700	0.05	0.26	0.52	0.78	1.04	2.08	3.12	4.16	6.24	10.39
725	0.05	0.24	0.48	0.73	0.97	1.94	2.91	3.88	5.81	9.69
750	0.05	0.23	0.45	0.68	0.91	1.81	2.72	3.62	5.43	9.05
775	0.04	0.21	0.42	0.64	0.85	1.70	2.54	3.39	5.09	8.48
800	0.04	0.20	0.40	0.60	0.80	1.59	2.39	3.18	4.77	7.96
850	0.04	0.18	0.35	0.53	0.70	1.41	2.11	2.82	4.23	7.05
900	0.03	0.16	0.31	0.47	0.63	1.26	1.89	2.52	3.77	6.29
950	0.03	0.14	0.28	0.42	0.56	1.13	1.69	2.26	3.39	5.64
1000	0.03	0.13	0.25	0.38	0.51	1.02	1.53	2.04	3.06	5.09
1500	0.01	0.06	0.11	0.17	0.23	0.45	0.68	0.91	1.36	2.26
2000	0.01	0.03	0.06	0.10	0.13	0.25	0.38	0.51	0.76	1.27

Tab. 18.4: Power density in MW/cm²

The durability of the measuring tips is not only dependent on the power density, but also on the purity of the surface (dust, particles, fingerprints). Measuring tips must therefore be handled with the utmost care.

18.4 Limit values for measuring operation with YAG high div measuring tip

Measuring tips can be operated up to the following maximum power densities:

Power	Maximum power density
Up to 5 kW	10 MW/cm²
Up to 12 kW	8 MW/cm²
Up to 20 kW	6 MW/cm²

Tab. 18.5: Power and maximum power density

The calculations are based on a tophat profile.

The maximum power density in actual beams with the same dimensions is often higher (typically plus 10 % to 60 %, plus 100 % for a Gaussian distribution). In case of doubt, start with a low laser power.

Arrangement in the table

Table element	White	Green	Yellow	Orange	White with red values
Speed in rpm	1875	3750	7500	7500 with inert gas purging	**Risk of destruction!**

Focus diameter in µm ↑ / Power in kW →	0.10	0.50	1.00	1.50	2.00	4.00	6.00	8.00	12.00	20.00
70	2.60	12.99	25.98	38.98	51.97	103.94	155.91	207.88	311.81	519.69
80	1.99	9.95	19.89	29.84	39.79	79.58	119.37	159.15	238.73	397.89
90	1.57	7.86	15.72	23.58	31.44	62.88	94.31	125.75	188.63	314.38
100	1.27	6.37	12.73	19.10	25.46	50.93	76.39	101.86	152.79	254.65
125	0.81	4.07	8.15	12.22	16.30	32.59	48.89	65.19	97.78	162.97
150	0.57	2.83	5.66	8.49	11.32	22.64	33.95	45.27	67.91	113.18
175	0.42	2.08	4.16	6.24	8.32	16.63	24.95	33.26	49.89	83.15
200	0.32	1.59	3.18	4.77	6.37	12.73	19.10	25.46	38.20	63.66
225	0.25	1.26	2.52	3.77	5.03	10.06	15.09	20.12	30.18	50.30
250	0.20	1.02	2.04	3.06	4.07	8.15	12.22	16.30	24.45	40.74
275	0.17	0.84	1.68	2.53	3.37	6.73	10.10	13.47	20.20	33.67
300	0.14	0.71	1.41	2.12	2.83	5.66	8.49	11.32	16.98	28.29
325	0.12	0.60	1.21	1.81	2.41	4.82	7.23	9.64	14.47	24.11
350	0.10	0.52	1.04	1.56	2.08	4.16	6.24	8.32	12.47	20.79
375	0.09	0.45	0.91	1.36	1.81	3.62	5.43	7.24	10.86	18.11
400	0.08	0.40	0.80	1.19	1.59	3.18	4.77	6.37	9.55	15.92
425	0.070	0.35	0.70	1.06	1.41	2.82	4.23	5.64	8.46	14.10
450	0.063	0.31	0.63	0.94	1.26	2.52	3.77	5.03	7.55	12.58
475	0.056	0.28	0.56	0.85	1.13	2.26	3.39	4.51	6.77	11.29
500	0.051	0.25	0.51	0.76	1.02	2.04	3.06	4.07	6.11	10.19
525	0.046	0.23	0.46	0.69	0.92	1.85	2.77	3.70	5.54	9.24
550	0.042	0.21	0.42	0.63	0.84	1.68	2.53	3.37	5.05	8.42
575	0.039	0.19	0.39	0.58	0.77	1.54	2.31	3.08	4.62	7.70
600	0.035	0.18	0.35	0.53	0.71	1.41	2.12	2.83	4.24	7.07
625	0.033	0.16	0.33	0.49	0.65	1.30	1.96	2.61	3.91	6.52
650	0.030	0.15	0.30	0.45	0.60	1.21	1.81	2.41	3.62	6.03
675	0.028	0.14	0.28	0.42	0.56	1.12	1.68	2.24	3.35	5.59
700	0.026	0.13	0.26	0.39	0.52	1.04	1.56	2.08	3.12	5.20
725	0.024	0.12	0.24	0.36	0.48	0.97	1.45	1.94	2.91	4.84
750	0.023	0.11	0.23	0.34	0.45	0.91	1.36	1.81	2.72	4.53
775	0.021	0.11	0.21	0.32	0.42	0.85	1.27	1.70	2.54	4.24
800	0.020	0.10	0.20	0.30	0.40	0.80	1.19	1.59	2.39	3.98
850	0.018	0.09	0.18	0.26	0.35	0.70	1.06	1.41	2.11	3.52
900	0.016	0.08	0.16	0.24	0.31	0.63	0.94	1.26	1.89	3.14
950	0.014	0.07	0.14	0.21	0.28	0.56	0.85	1.13	1.69	2.82
1000	0.013	0.06	0.13	0.19	0.25	0.51	0.76	1.02	1.53	2.55
1500	0.006	0.03	0.06	0.08	0.11	0.23	0.34	0.45	0.68	1.13
2000	0.003	0.02	0.03	0.05	0.06	0.13	0.19	0.25	0.38	0.64
3000	0.001	0.01	0.01	0.02	0.03	0.06	0.08	0.11	0.17	0.28

Tab. 18.6: Power density in MW/cm²

The durability of the measuring tips is not only dependent on the power density, but also on the purity of the surface (dust, particles, fingerprints). Measuring tips must therefore be handled with the utmost care.

18.5 Check/replace the measuring tip

18.5.1 Check the measurung tip

NOTICE

Damage/Destruction of the measuring tip

The very small pinhole of the measuring tip can quickly become blocked by dirt particles or when touched with the bare hands.

▶ **Wear powder-free latex gloves during assembly/disassembly and ensure that the environment is free of dirt and dust.**

You can use the HeNe laser to check that there is space for the measuring tip to pass through when in doubt. Remove the measuring tip and light up the measuring tip with a 0.5 to 1.0 mW laser from behind. There should be a clear red reflex through the pinhole.

18.5.2 Disassemble the measuring tip

1. Turn off the supply voltage.
2. Turn the FocusMonitor FM+ upside down.
3. Turn the rotational disk until the measuring tip becomes visible in the housing recess.
4. Remove the fastening screws of the retaining plate (Torx T8) (see Fig. 18.1 on page 52).

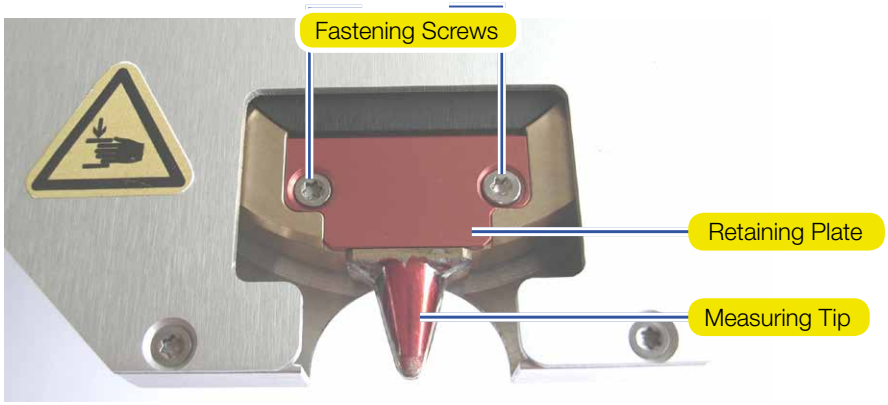


Fig. 18.1: Measuring, view from below

5. Carefully push the measuring tip and retaining plate upwards through the housing bore using a screwdriver (see Fig. 18.2 on page 52).

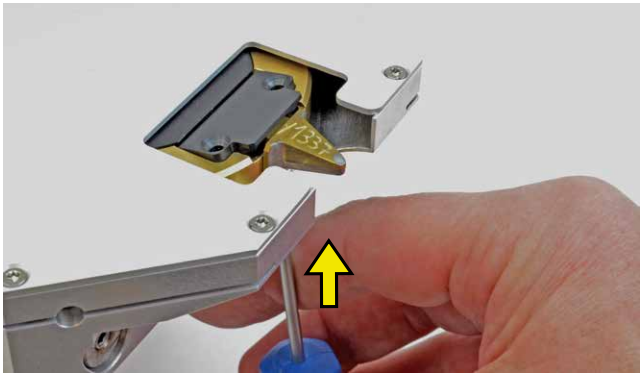


Fig. 18.2: Pushing out the measuring tip

6. Pull the retaining plate up slightly and then forwards until it loosens and can be removed easily.
7. Carefully remove the measuring tip.

18.5.3 Assemble the measuring tip

1. Insert the new measuring tip (note that the inlet aperture is located on the convex side, see Fig. 18.3 on page 53) or turn the measuring tip around.

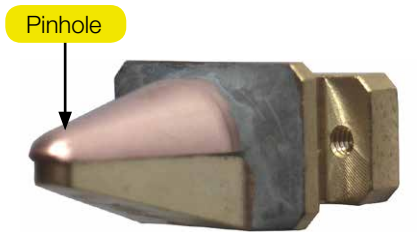


Fig. 18.3: Inlet aperture (pinhole) in the measuring tip

2. Use up and down movements to insert the retaining plate into the rotational disc at an angle of about 45 degrees, ensuring that the guide groove is pointing upwards. Then push it down into the recess (see Fig. 18.4 on page 53).
3. Check whether the retaining plate is positioned correctly by lightly pressing the front edge.

Fig. 18.4: Inserting the retaining plate

4. Insert the fastening screws (Torx T8) and tighten manually.

If you have turned the measuring tip, use the arrow buttons to select the “Measuring Tip” setting in LaserDiagnosticsSoftware LDS in the menu ***Device control > Advanced > Measuring tip***.

18.6 Replace the detector

Generally, the FocusMonitor FM+ is equipped with a DFIG-PS+ or DFC+ detector (see Fig. 18.5 on page 54). Detectors with different sensitivity or different time behavior can be used for special applications. More information regarding the variety of detectors to ensure an optimum configuration of the FocusMonitor FM+ is provided in the Tab. 18.1 on page 47.

NOTICE

Damage of the detector

Touching the sensor surface will damage the detector. This can negatively affect the measuring results.

- **Do not touch the detector with your fingers on the sensor surface.**
- **Don't set the detector on the sensor surface.**

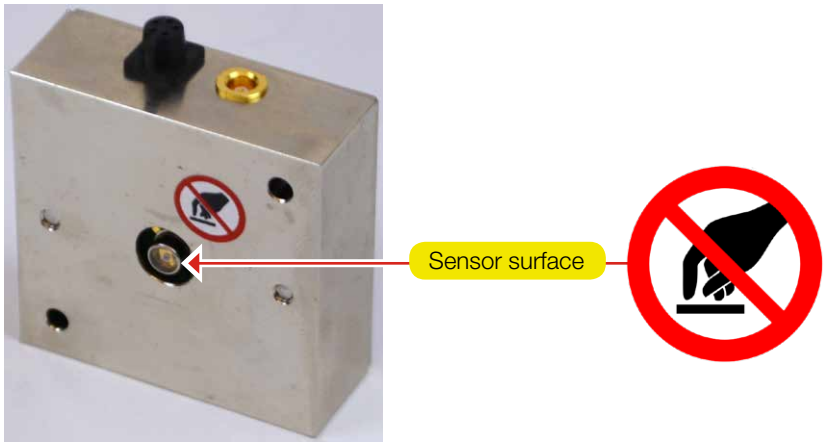


Fig. 18.5: Sensor surface on the detector

18.6.1 Disassemble the detector

1. Turn off the power supply.
2. Remove the plastic screws (D) from the detector (see Fig. 18.6 on page 55).

Fig. 18.6:

3. Carefully remove the detector from the position.

▶ Please do not pull the cables.

4. First loosen the golden angle plug (A), then the black plug (B) (see Fig. 18.7 on page 55).

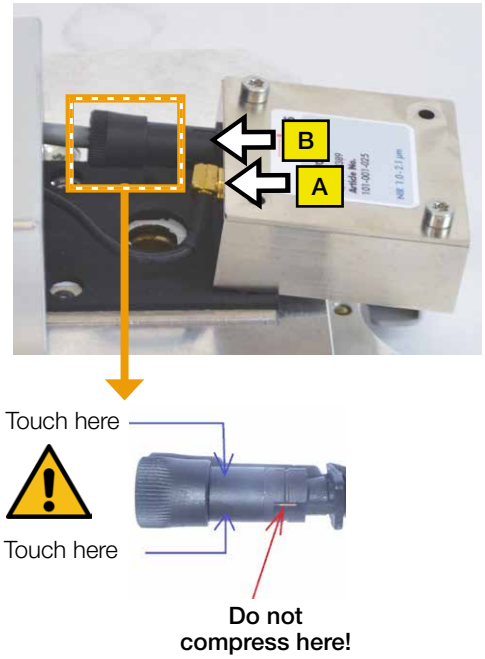


Fig. 18.7: Releasing the plugs from the detector

18.6.2 Assemble the detector

Only use isolating plastic screws to fasten the detector to prevent any electric noise signals from being interspersed. Do not forget the foam rubber spacer during installation, otherwise the rotational disc could be mechanically blocked by the screws. The foam rubber spacer also ensures mechanical decoupling of the detector.

1. To install the new detector, first place the foam rubber spacer (C) on the mounting surface of the detector. Then connect the cables. Align the detector in such a way that a space is maintained to the housing on both sides (see Fig. 18.8 on page 56).

NOTICE

Blocking the rotational disc

If the screws are tightened too firmly, they might block the rotational disc!

- ▶ **Only tighten the screws hand-tight. The foam rubber spacer must only be compressed to no more than half its original thickness.**

2. Fasten the detector with the two plastic screws (D).

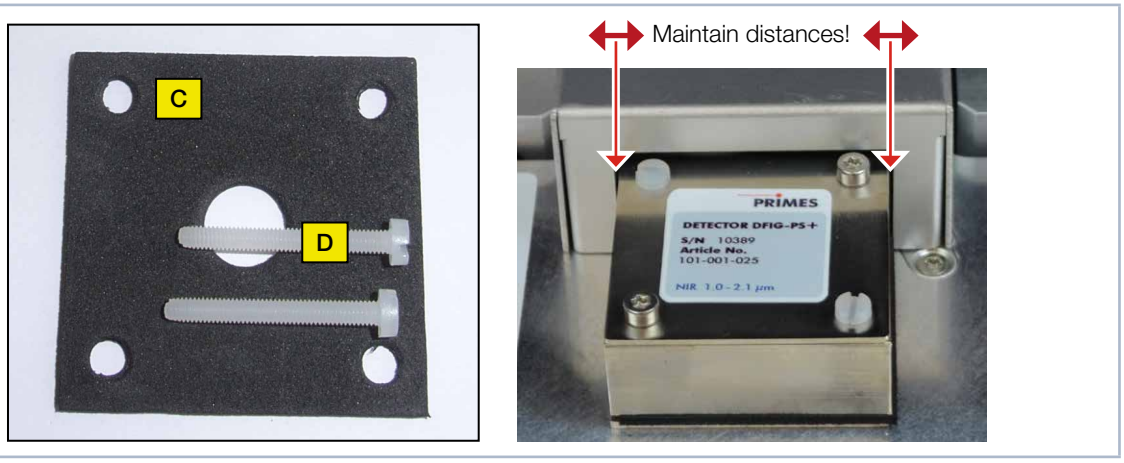


Fig. 18.8: Assembling a new detector