PRIMES

Original Instructions

FocusMonitor FM+ HPD

LaserDiagnosticsSoftware LDS

Revision 03 EN - 03/2026

IMPORTANT!

READ CAREFULLY BEFORE USE.

KEEP FOR FUTURE USE.

Table of contents

PRIMES - the company

PRIMES is a manufacturer of measuring devices for the analysis of laser beams.

These devices are used for the diagnostics of high-power lasers. This ranges from CO_2 lasers to solid-state and fiber lasers to diode lasers and the wavelength ranges from IR to near UV.

A wide range of measuring devices is available 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

Development, production and calibration of the measuring devices is performed at PRIMES. 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 device has been designed exclusively for measurements within the beam of high-power lasers.

Use for any other purpose is considered as not intended and is strictly prohibited. Furthermore, intended use requires that all information, instructions, safety notes and warning messages in this operating manual are observed. The specifications given in chapter 14, „Technical data“, on page 72 apply. Any given limit values must be complied with.

If not used as intended, the device or the system in which the device is installed can be damaged or destroyed. In addition, there is an increased risk to health and life. Only use the device in such a way that there is no risk of injury.

This operating manual is an integral part of the device and must be kept in the immediate vicinity of the place of use, accessible to personnel at all times.

Every person who is responsible for the installation, start-up or operation of the device must have read and understood the operating manual and, in particular, the safety instructions.

If you still have questions after reading this operating manual, please contact PRIMES or your supplier for your own safety.

Observing applicable safety regulations

Observe the safety-relevant laws, guidelines, standards and regulations in the current editions published by the state, standardization organizations, professional associations, etc. In particular, observe the regulations on laser safety and comply with their requirements.

Necessary safety measures

The device measures direct laser radiation, but does not emit any radiation itself. However, during the measurement the laser beam is directed at the device. This produces scattered or directed reflection of the laser beam (laser class 4). The reflected beam is usually not visible.

Warning – Laser Radiation

During the measurement the laser beam is reflected from the rotating measuring tip. This produces scattered or directed reflection of the laser beam (laser class 4). Depending on the wavelength of the laser, the reflected beam is usually invisible.

To avoid injury from the reflected laser beam, no one should be in the hazardous area where the measurement is taking place. The hazardous area must be defined before operation of the FM+ HPD.

During operation of the device, the laser radiation must be fully absorbed after passing through the measurement zone. A suitable absorber must be used for this purpose.

Depending on the application, PRIMES offers suitable laser power meters. Appropriate PRIMES laser power meters can be found in chapter 7.2.5, „Install the FocusMonitor FM+ HPD“, on page 22.

When working with the device, people in the hazardous area must protect themselves by taking the following protective measures.

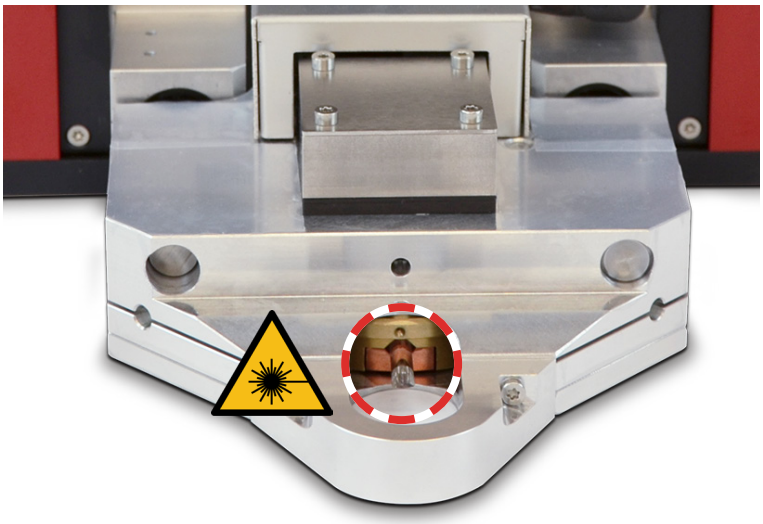


Fig. 1.1: Risk of injury from scattered or directed reflections of the laser beam.

DANGER

Serious eye or skin injury due to laser radiation

The device measures direct laser radiation, but does not emit any radiation itself. However, during the measurement the laser beam is reflected at the rotating FS³. This produces scattered or directed reflection of the laser beam (laser class 4). The reflected beam is usually not visible.

- ▶ **In measurement mode, a safety distance of one meter to the device must be maintained even when wearing safety goggles and safety clothing.**
- ▶ **Protect yourself from direct and reflected laser radiation while working with the device by taking the following measures:**

- Never leave the device unattended when taking measurements.
- Wear **safety goggles** adapted to the power, power density, laser wavelength and operating mode of the laser beam source in use.
- Wear suitable **protective clothing** or **protective gloves** if necessary.
- If possible, also protect yourself from direct laser radiation and scattered radiation by using separating protective devices that block or attenuate the radiation.
- If the device is moved from its aligned position, increased scattered or directed reflection of the laser beam occurs during measuring operation. Mount the device in such a way that it cannot be moved unintentionally, i.e. by bumping or pulling the cables.
- Install safety switches or emergency safety mechanisms that allow the laser to be switched off immediately.
- Use suitable beam guidance and beam absorber elements which do not emit any hazardous substances when irradiated.

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 may not be modified in terms of design or safety without the explicit consent of the manufacturer. The same applies to unauthorized opening, dismantling and repair. The removal of covers is only permitted within the scope of the intended use.

Liability disclaimer

Manufacturer and distributor exclude any liability for damages and injuries which are direct or indirect consequences of using the device not as intended or modifying the device or the associated software without authorization.

2 Symbol explanations

Warning messages

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.

Product safety labels

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

Read and understand the operating manual before using the device!

Hand injuries warning

General warning sign

Labeling according to WEEE directive:

The device must not be disposed of with household waste, but in a separate WEEE collection in an environmentally friendly way.

Further icons and conventions in this operating manual

Here you will find useful information and helpful tips.

▶ Indicates a single instruction.

If several of these instructions appear one below the other, the order in which they are executed is irrelevant or they represent alternative courses of action.

1. A numbered list identifies a sequence of instructions that must be executed in the specified order.
2.
...

→ Indicates the result of an action to explain processes that take place in the background.

Indicates an observation prompt to draw attention to visible feedback from the device or the software.

Observation prompts make it easier to check whether an instruction was executed successfully. Often they also guide to the next instruction.

Points to a control element that is to be pressed / clicked.

Points to an element described in the text (for example an input field).

3 About this operating manual

This manual describes the installation and operation of the FocusMonitor FM+ HPD and performing measurements with the LaserDiagnosticsSoftware LDS, version 1.4 or later. Throughout this operating manual, the abbreviations FM+ HPD and LDS will be used.

For measurement operation with a PC, the LDS must be installed on the PC.

PRIMES will be happy to provide you with a current download link. For this purpose, contact your sales partner or send an e-mail to: ***support@primes.de***

This manual includes a brief introduction on using the LDS for measurements. For a detailed description of the software installation, file management and evaluation of the measurement data, please refer to the separate instructions for the LDS.

This operating manual describes the software version valid at the time of printing. Since the LDS is subject to continuous development, it is possible that a newer version will be available.

4 Device description

4.1 Functional description

The FM+ HPD (High Power Densities) measures the beam properties of focused laser beams. In addition to the geometric dimensions of the focused laser beam, the focal position in space, the beam parameter product as well as the beam quality factor M^2 are determined.

The laser beam is scanned across the x-axis with a rotating FS^3 (Fused Silica Sensor System) measuring tip. The integrated horizontal and vertical carrier moves the FS^3 in the y- and z-axes, so that the beam properties of the focused laser beam can be measured spatially.

This enables automatic measuring of complete caustics over a length of up to120 mm.

The FM+ HPD works with the PRIMES LDS and is equipped with an Ethernet interface for fast and secure data transfer.

When the FM+ HPD is in operation, the laser radiation that has passed through the measuring zone must be completely absorbed.

The FS^3 measuring tip is equipped with a protective shield to prevent damage and slow down flying glass fragments in the event of destruction. Therefore, do not operate the device without the touch protection.

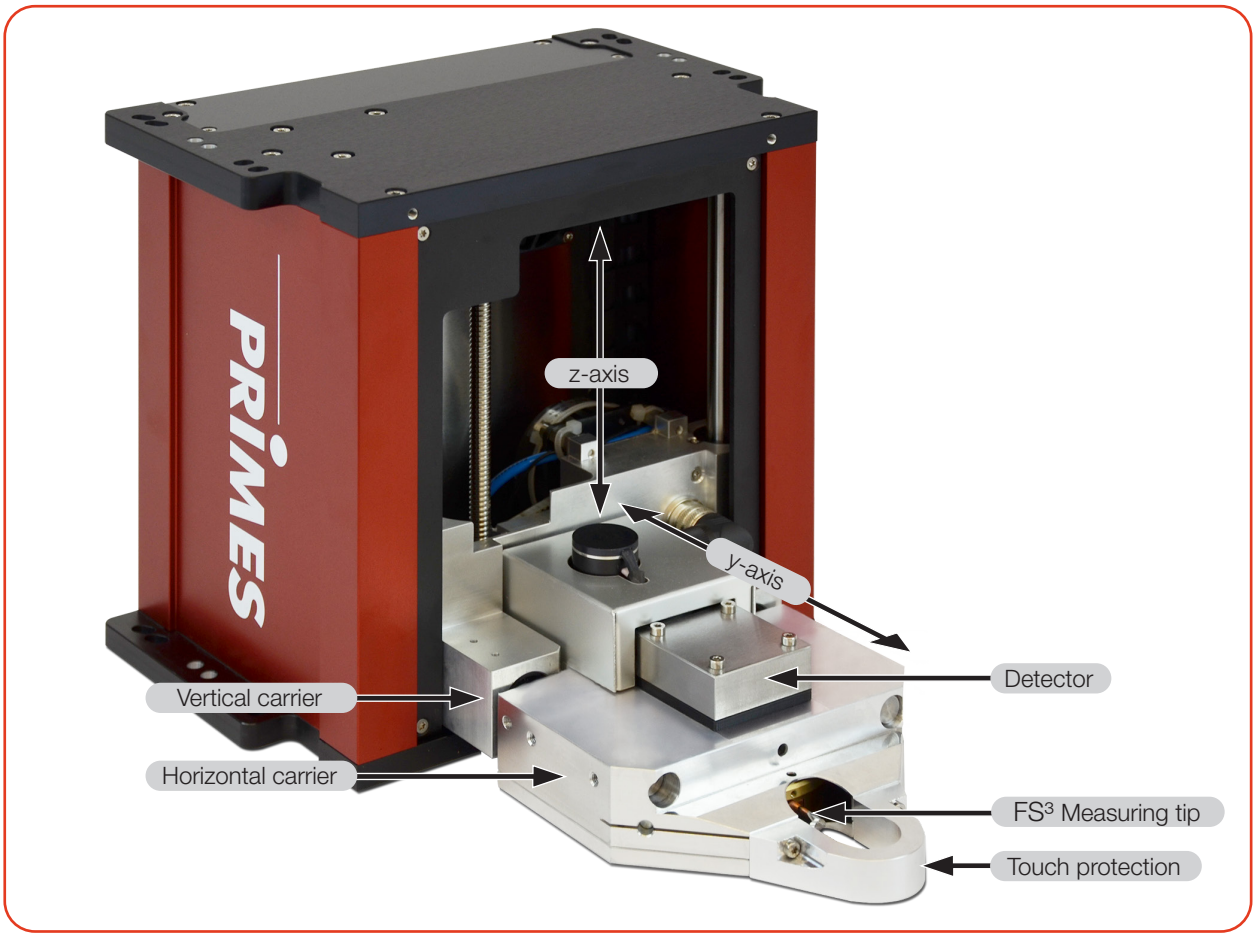


Fig. 4.1: Components of the FocusMonitor FM+ HPD

4.2 Measuring principle

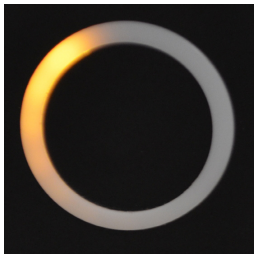
The FocusMonitor FM+ HPD (High Power Density) is used to analyze focused laser beams. The device measures the spatial power density distribution within the focus range of the processing optics. From the measured power density distributions, the LaserDiagnosticsSoftware LDS calculates the beam diameters and derives beam parameters such as the focus diameter, the spatial focus position and the beam quality factor M^2.

The FocusMonitor FM+ HPD with the new fused silica sensor system FS^3 is designed for particularly high power densities up to 50 MW/cm^2. The power density distribution in the focus is measured with the FocusMonitor FM+ HPD using a rotating FS^3, which rotates in the x-direction and scans the beam cross section line by line in the y-direction.

The very small scatter structure in the FS^3 separates out a small part of the laser beam. A mirror then guides the measuring signal to a detector. The FS^3 is automatically moved in z direction by a vertical carrier. This ensures that the propagation parameters can be determined in full by moving along the beam caustic.

4.3 Status display

The status display consists of a light ring that uses different colors and static or rotating lights to indicate different states of the FM+ HPD.



Color	Lightingstage	Meaning
White	The entire ring is lit	Supply voltage is connected
Yellow	Rotating light	The measuring tip is rotating and the different rotational speeds are indicated.
Red	Rotating light	The measuring is tip rotating and the y-axis is moving.The measurement is in progress, the different rotational speeds are indicated.

Tab. 4.1: States of status display

4.4 Explanation of the product safety labels

A potential hazard area for hand injuries is marked with a symbol “Hand injuries warning“ on the device.

Warning of hand injuries from the rotating measuring tip

The measuring tip of the FM+ HPD rotates at high speed during the measuring operation. Even after the measurement or switching off the device, the measuring tip will continue to rotate for a certain period of time. To avoid hand injury, do not reach into the device aperture when the measuring tip is rotating.

If the rotating measuring tip hits an obstacle, the measuring tip will be damaged. In this case, the device must be sent in for service. Therefore, no objects may be held in the measurement area of the device.

After switching off the rotation or the device, wait for the measuring tip to come to a standstill (observe the „Rotation“ status display), see chapter 4.3 „Status display“ on page 13).

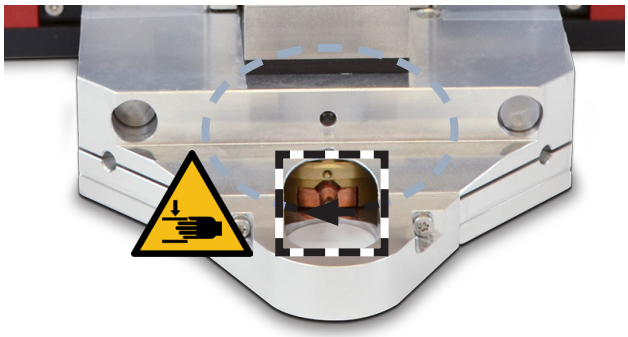


Fig. 4.2: Risk of injury due to a rotating measuring tip

Warning of hand injuries in the travel range of the carriers

The horizontal and vertical carrier can be moved relative to the housing. Do not reach into the travel range of the carriers.

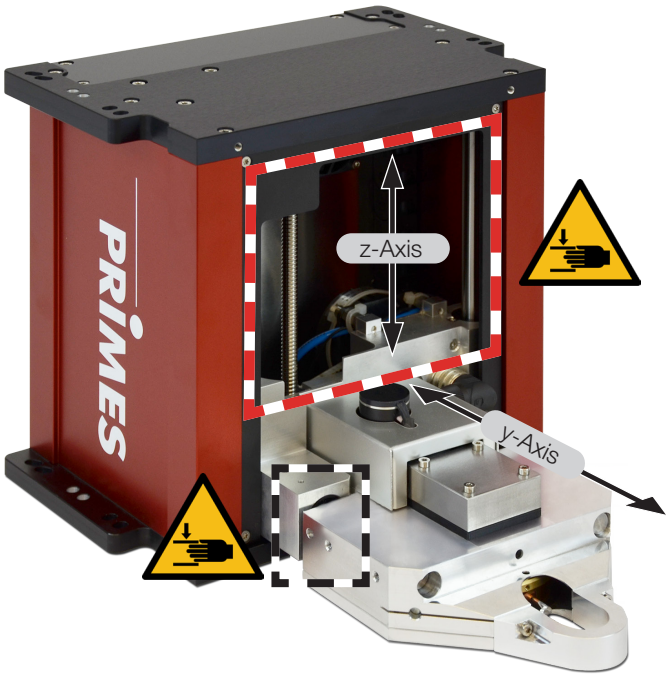


Fig. 4.3: Risk of injury in the travel range of the carriers

4.5 Scope of delivery and accessories

The following parts are included in the scope of delivery:

- FM+ HPD
- PRIMES power supply
- Power cable
- Fused Silica Sensor System FS³
- Alignment Tool
- Patch Kabel Cat.5e, 5 m, Cross-Over
- Patch Kabel Cat.5e, 5 m
- PRIMES USB flash drive (PDF of operating manual, software, etc.)
- Operating Manual FM+ HPD
- Operating Manual LaserDiagnosticsSoftware LDS
- Transport and Storage Case

The following accessories are available:

- Rotating disk for conventional measuring tip
- conventional measuring tip

5 Transport and Storage

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.**

NOTICE

Damage/Destruction of the FS³

Touching the FS³ can lead to burn-in by the laser radiation at the points of contact. Burn-in lead to damage or bursting of the FS³.

▶ **Do not touch the FS³.**

Transportation and storage in the optional transport and storage case

In order for the device to fit into the optional transport and storage case, the carriers must be moved to the park position before being switched off, see chapter 9.3.3, „Disconnect device from the LDS and switch off“, on page 32.

▶ Optionally switch the device off and on again. The carriers of the device move to the park position after approx. 10 seconds.

6 Installation and configuration on PC

6.1 Install LaserDiagnosticsSoftware LDS

The LDS in the basic version is included in the device scope of delivery. PRIMES will also gladly provide you with a current download link upon request. Please contact your sales partner or email: **support@primes.de.**

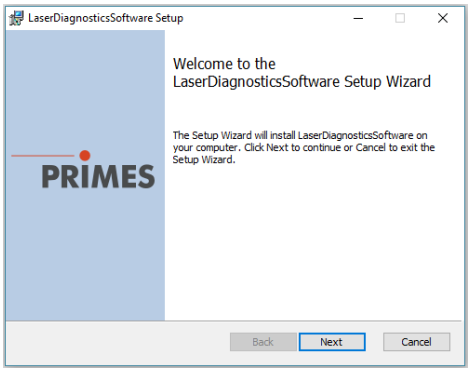
1. Please ensure:
- System requirements are met.
- You have administrator rights.
2. Close all programs on your PC.
3. Insert the PRIMES USB flash drive into your PC and open the directory.

System requirements:

- Intel Pentium Core i3 or better
- Windows 10 (64-bit version)
- At least 4 GB RAM; 8 GB RAM recommended
- Display resolution: Full HD (1 920 x 1 080)
- A USB-or Ethernet port to connect the device

4. Double-click the ***LDS_Setup.exe*** file to start the installation.
5. Follow the instructions on the screen.

➔ The default storage location for the mainprogramm ***LaserDiagnosticsSoftware.exe*** is: ***C:\Programs\Primes\Software***.



6.2 Configuration of the PC IP-adress

The PC must be in the same IP address network as the PRIMES device.

Choose one of the following options to connect to a PC. The IP address of the PRIMES device can only be changed when connected to a PC (see chapter 9.3.2, „Change IP address of a connected device“, on page 31).

6.2.1 Integration into a network

Within the PRIMES device, the option DHCP (Dynamic Host Configuration Protocol) is activated by default. The device obtains its IP address from the DHCP server.

6.2.2 Direct connection to a PC

In ***Windows > Control panel > Network and Sharing Center***, assign an IP address to your PC that is in the same address range as the PRIMES device (e.g. 192.168.116.xyz). The first three number blocks must be identical, the last number block can be freely selected. The IP address should be entered by a system administrator.

The static IP address of the PRIMES device is located on the nameplate

7 Mounting

7.1 Conditions at the installation site

- The device must not be operated in a condensating atmosphere.
- The ambient air must be free of gases and aerosols that interfere with the laser radiation (e.g. organic solvents, cigarette smoke, sulfur hexafluoride).
- Protect the device from spray water and dust.
- Operate the device in closed rooms only.

7.2 Integration into the laser system

DANGER

Serious eye or skin injury due to glass splinters

A mechanical damage to the FS³ can destroy it during measurement operation. Due to the high speed of the FS³, ejected glass splinters can lead to severe injuries of the skin, the eyes or even to a loss of vision.

- ▶ **Do not operate the device without the curved touch protection in front of the FS³.**
- ▶ **Protect yourself by placing an appropriate shielding wall between the device and the area where people are present.**

DANGER

Fire and explosion hazards due to scattered or directed laser radiation

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

- ▶ **Use a suitable absorber. PRIMES offers, depending on the application, suitable laser power meters for permanent absorption, e.g. the PowerMonitor PM 48/100.**
- ▶ **Don't store any flammable materials or highly flammable substances at the measuring location.**

NOTICE

Damage/Destruction of the device

Obstacles in the movement range of the horizontal and vertical carrier can lead to collisions and damage the device.

- ▶ **Keep the movement range free of obstacles (cutting nozzle, pressure rolls, etc.).**
  Please note that the horizontal and vertical carrier 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.

7.2.1 Prepare mounting

1. Switch off the laser beam.

2. Ensure that moving parts, e.g. robot arms, etc. are at a standstill and that they cannot be set in motion unintentionally.

3. Check the space available before installing the device, especially the required space for the connection cables.

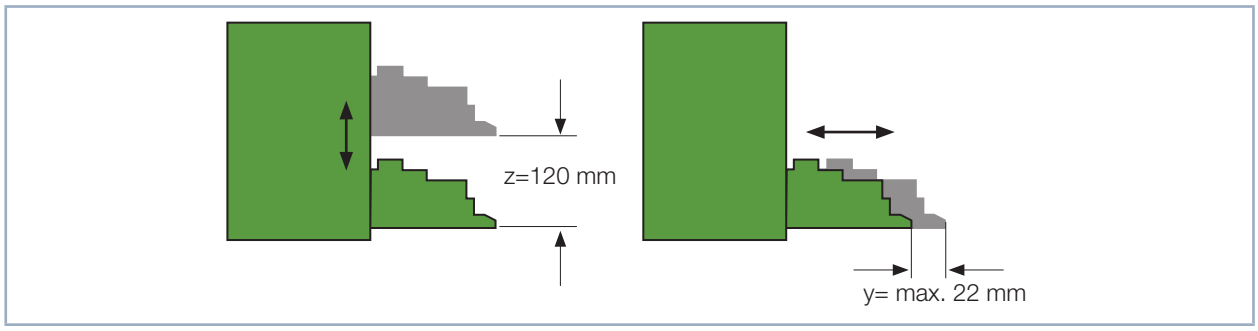


Fig. 7.1: Movement range of the horizontal and vertical carrier

The range of motion of the horizontal and vertical carrier can be restricted in the LDS (locked area). A locked area can be set according to chapter 15, „Dimensions“, on page 73 .

7.2.2 Installation position

The device can be installed in any mounting position. The position and diameter of the mounting holes on the top and bottom of the device are identical.

Standard mounting

The standard position of the device is intended for beam incidence from above

Mounting with Horizontal Beam Incidencel

For operation with horizontal beam incidence, the device can also be installed on a vertical mounting surface. The device can be mounted with the carriers pointing up or down. Pay particular attention to secure fastening in this mounting position.

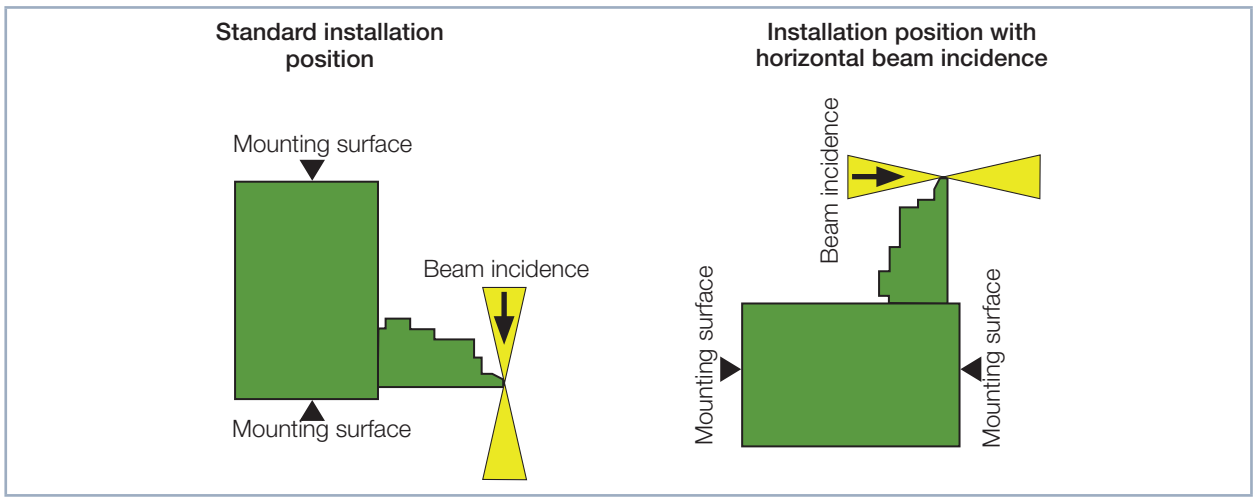


Fig. 7.2: Installation position

7.2.3 Remove/insert the dust protection of the FS³

The dust protection protects the FS³ from mechanical damage and from contamination (see Fig. 7.3 on page 19).

The dust protection must be removed before each measurement and reinstalled after the measurement has been completed.

The dust protection consists of an upper part with the identification TOP and a lower part. The two parts are connected with inserted magnets. If the dust protection is in the correct position, it is in contact with the touch protection without gaps.

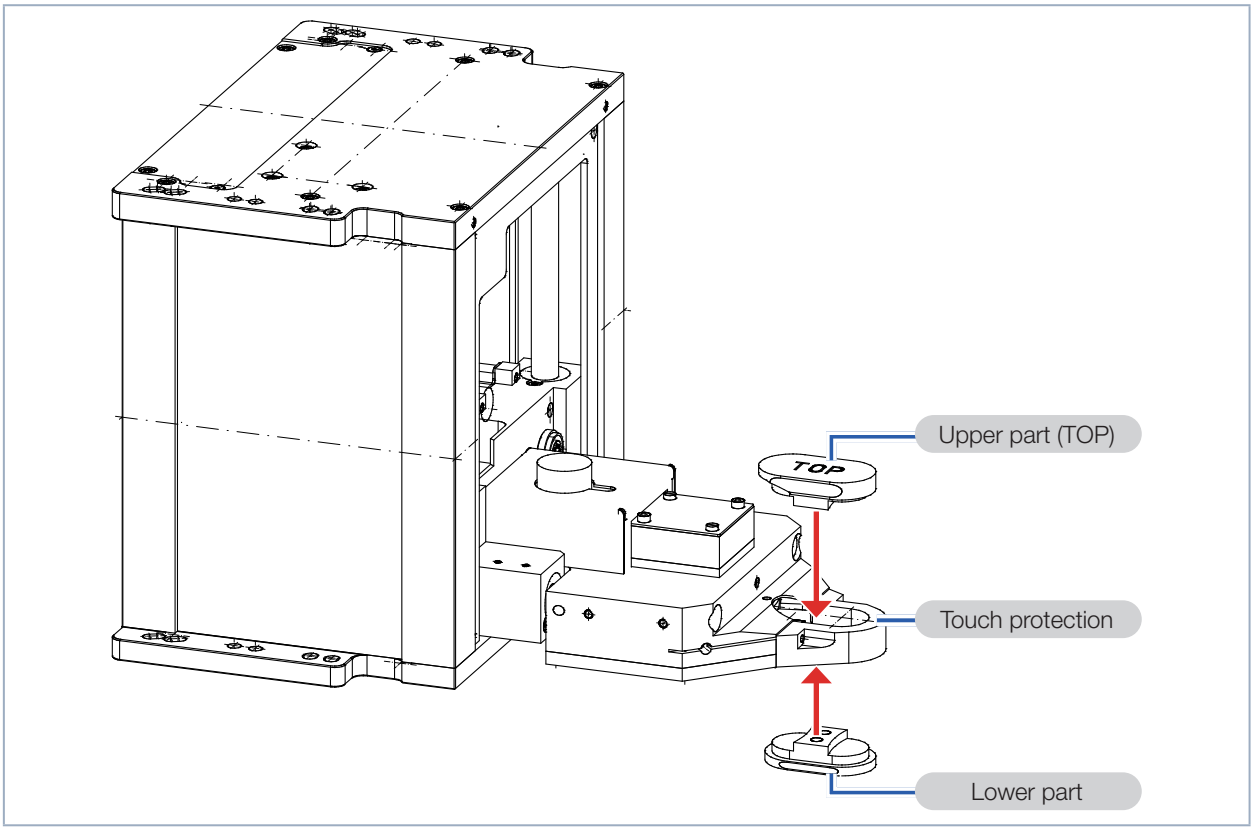


Fig. 7.3: Remove/insert the dust protection

7.2.4 Align the device

Only use a pilot laser for alignment.

DANGER

Serious eye or skin injury due to laser radiation

If the laser beam hits the FS³ located in the inlet aperture, scattered or directed reflection of the laser beam occurs (laser class 4).

▶ Wear powder-free latex gloves and move the FS³ out of the inlet aperture.

CAUTION

Risk of injury caused by rotating or moving parts

The linear movement of the horizontal and vertical carrier and the rotating FS³ pose an injury hazard.

▶ Do not reach into the movement range of the horizontal and vertical carrier.

▶ Only align the FocusMonitor FM+ HPD while the FS³ is stationary.

Devices' position in relation to the laser beam

For the FocusMonitor FM+ HPD, the beam must enter vertically to the x-y-plane

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 focus plane should be centered to the measuring range of the FocusMonitor FM+ HPD

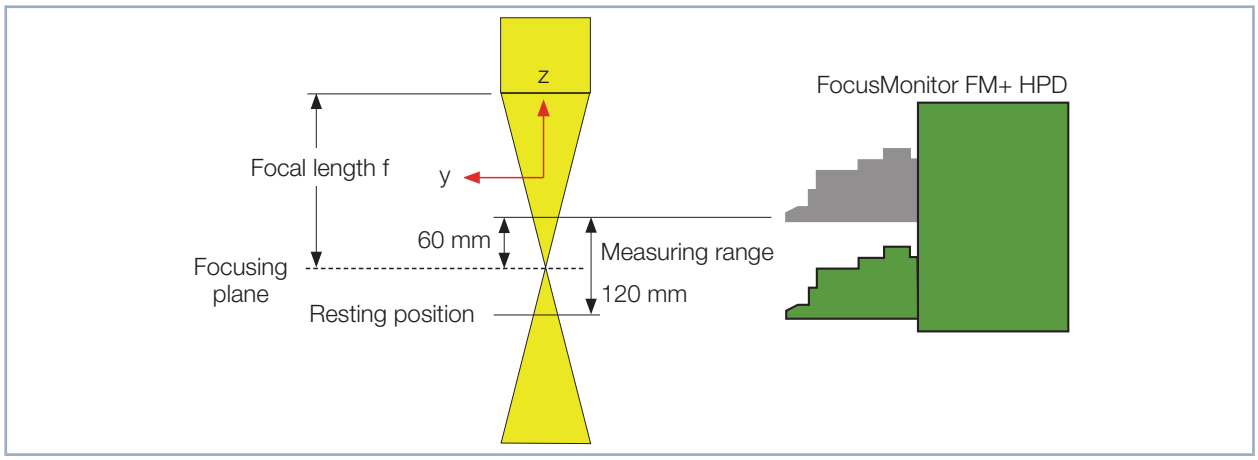


Fig. 7.4: Measuring range of FocusMonitor FM+ HPD

Align the FocusMonitor FM+ HPD with the alignment tool

An alignment tool (see Fig. 7.5 on page 21) is included with the device for easy alignment (x-y-plane) to the laser beam.

1. Connect the FocusMonitor FM+ HPD with the LaserDiagnosticsSoftware LDS as described in chapter on page 4.
2. Choose the function scanner of the FocusMonitor FM+ HPD as described in chapter chapter 9.4.2, „Open the device control menu“, on page 34.
3. In accordance with chapter 9.4.3 on page 34, 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. 7.4 on page 20) without a rotated FS³.

4. Remove the dust protection according to chapter 7.2.3 on page 19.
5. Place the Alignment tool on the horizontal carrier
6. Turn on the pilot laser and align the device:

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

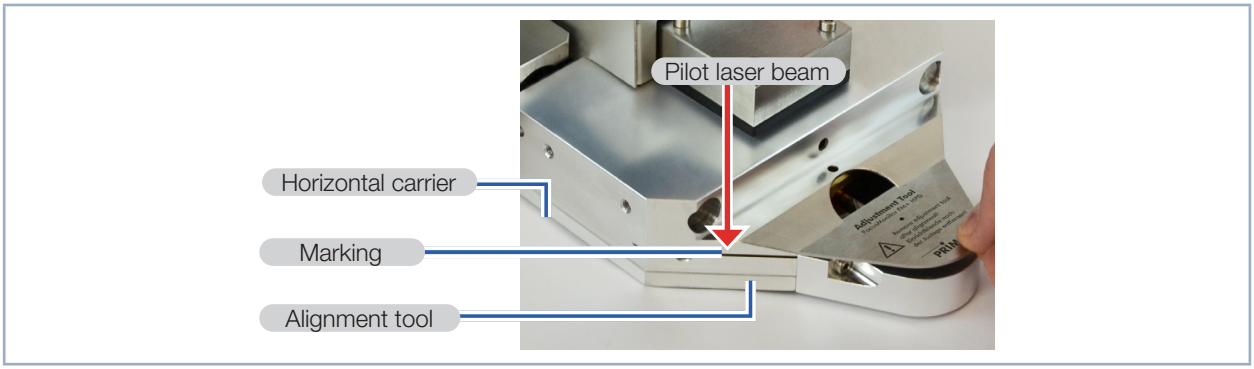


Fig. 7.5: Alignment tool at the horizontal carrier of FocusMonitor FM+ HPD

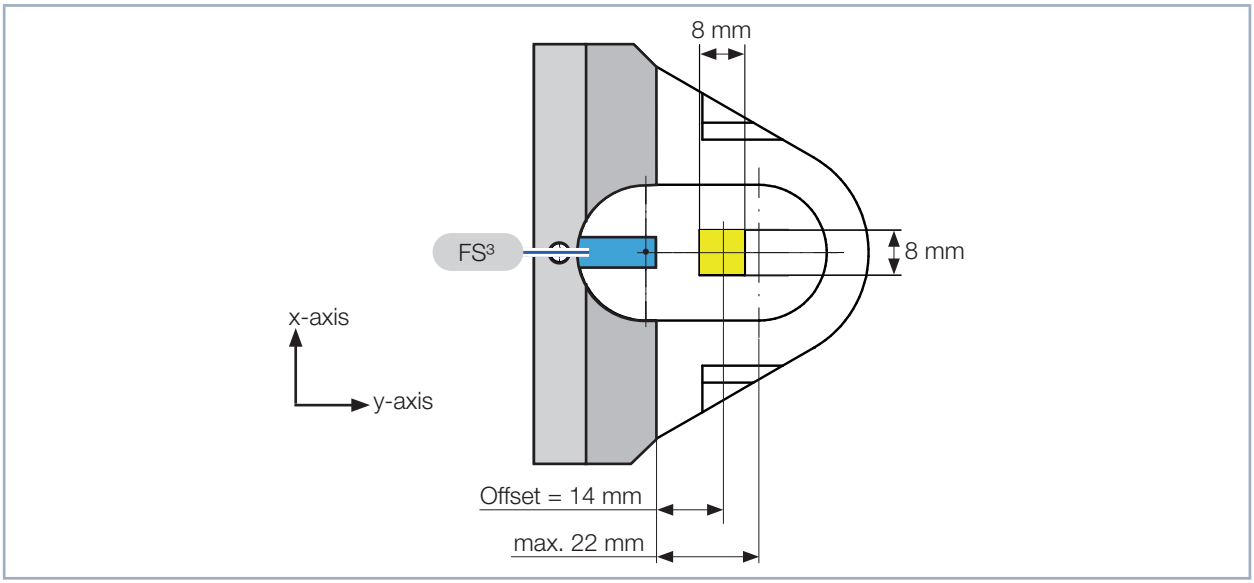


Fig. 7.6: Offset of a measurement window size of 8 x 8 mm

7.2.5 Mount the device

DANGER

Serious eye or skin injury due to laser radiation

If the device is moved from its aligned 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^{H7} mm for assembly on a support bracket provided by the customer or the PowerMonitor PM (see Fig. 7.7 on page 22).

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.

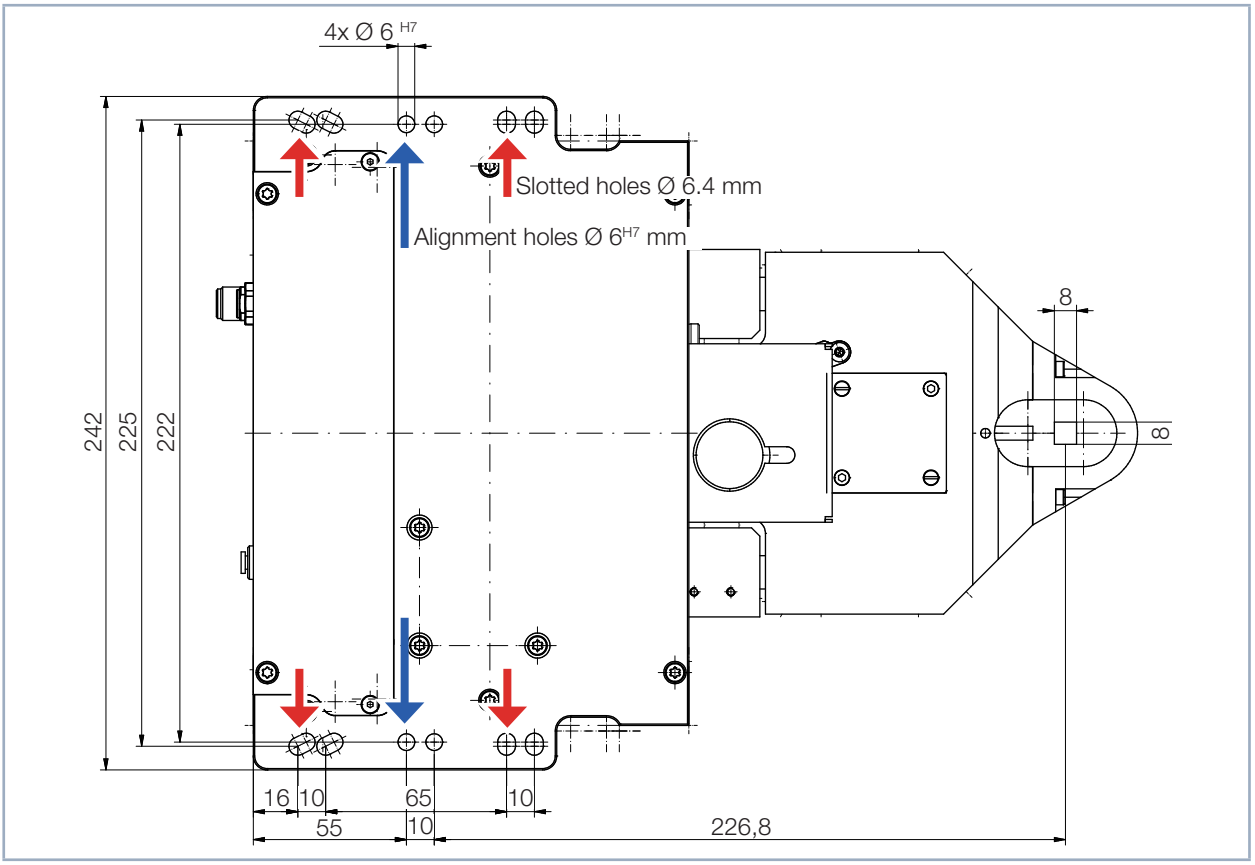


Fig. 7.7: Mounting holes, view from above (same hole pattern below)

7.2.6 Connection of the FocusMonitor FM+ HPD and a laser power measurement device

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.

▶ Connect/disconnect all plugs in a de-energized state only.

For sufficient absorption of the radiation behind the measurement zone, the PRIMES PowerMonitor PM 48/100 can be used.

The water-cooled PowerMonitor PM 48/100 measures the laser power and provides additional information on cooling water flow and temperature.

The laser power meter is connected via the PRIMES bus (RS485 interface). The pin assignment of the RS485 interface can be found in chapter 8.4, „PRIMES Bus-RS485“, on page 25

When connecting several devices, always use only one PRIMES power supply unit on the FocusMonitor FM+ HPD for powering the devices.

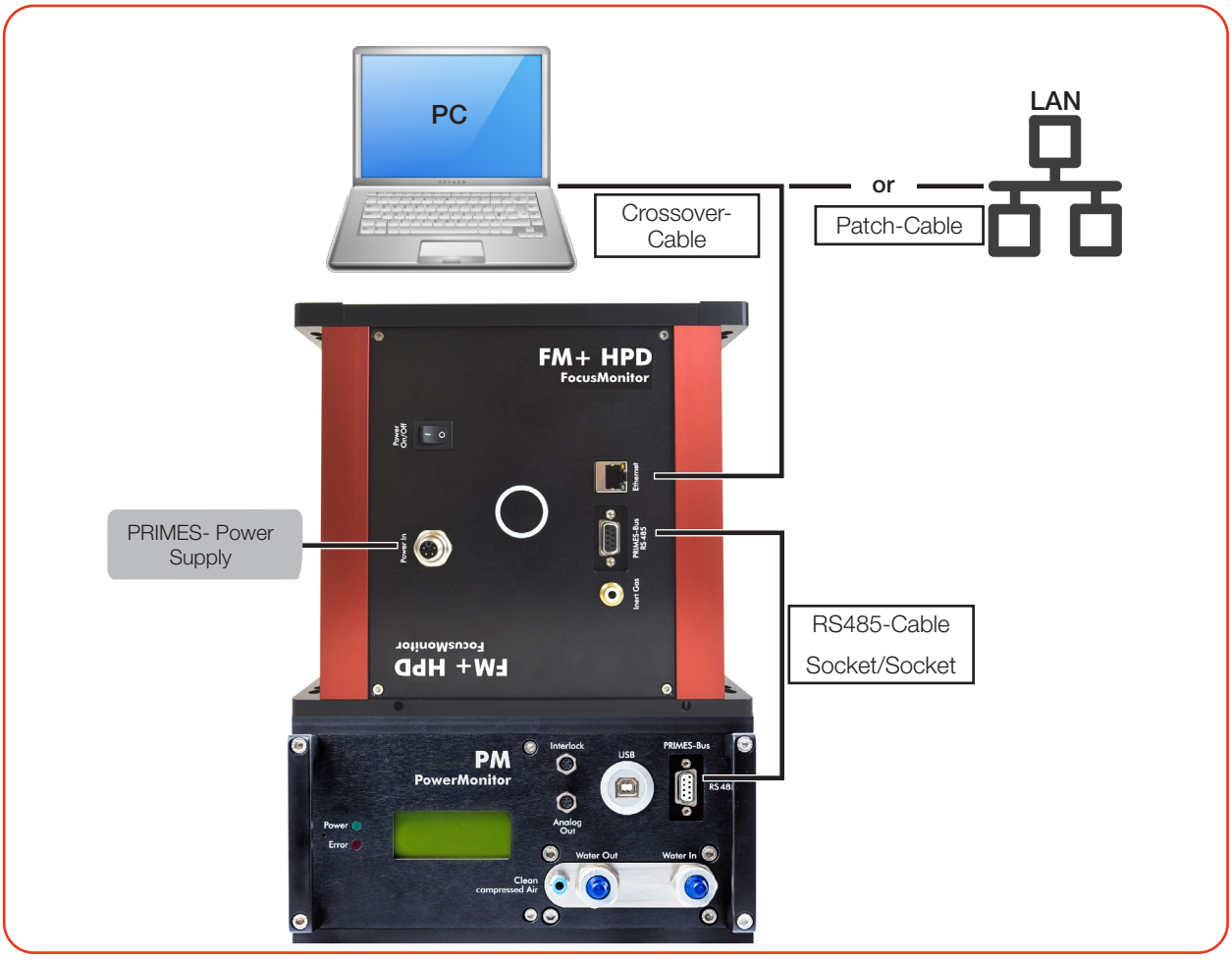


Fig. 7.8: Connection of the FocusMonitor FM+ HPD and PowerMonitor PM 48/100 to the PC

7.3 Removal from the laser system

1. Switch off the laser beam.
2. Ensure that moving parts, e.g. robot arms, etc. are at a standstill and that they cannot be set in motion unintentionally.
3. Switch off the power supply.
4. Unscrew the fastening screws.
5. Remove the device from the laser system.

8 Connections

8.1 Connections overwiew

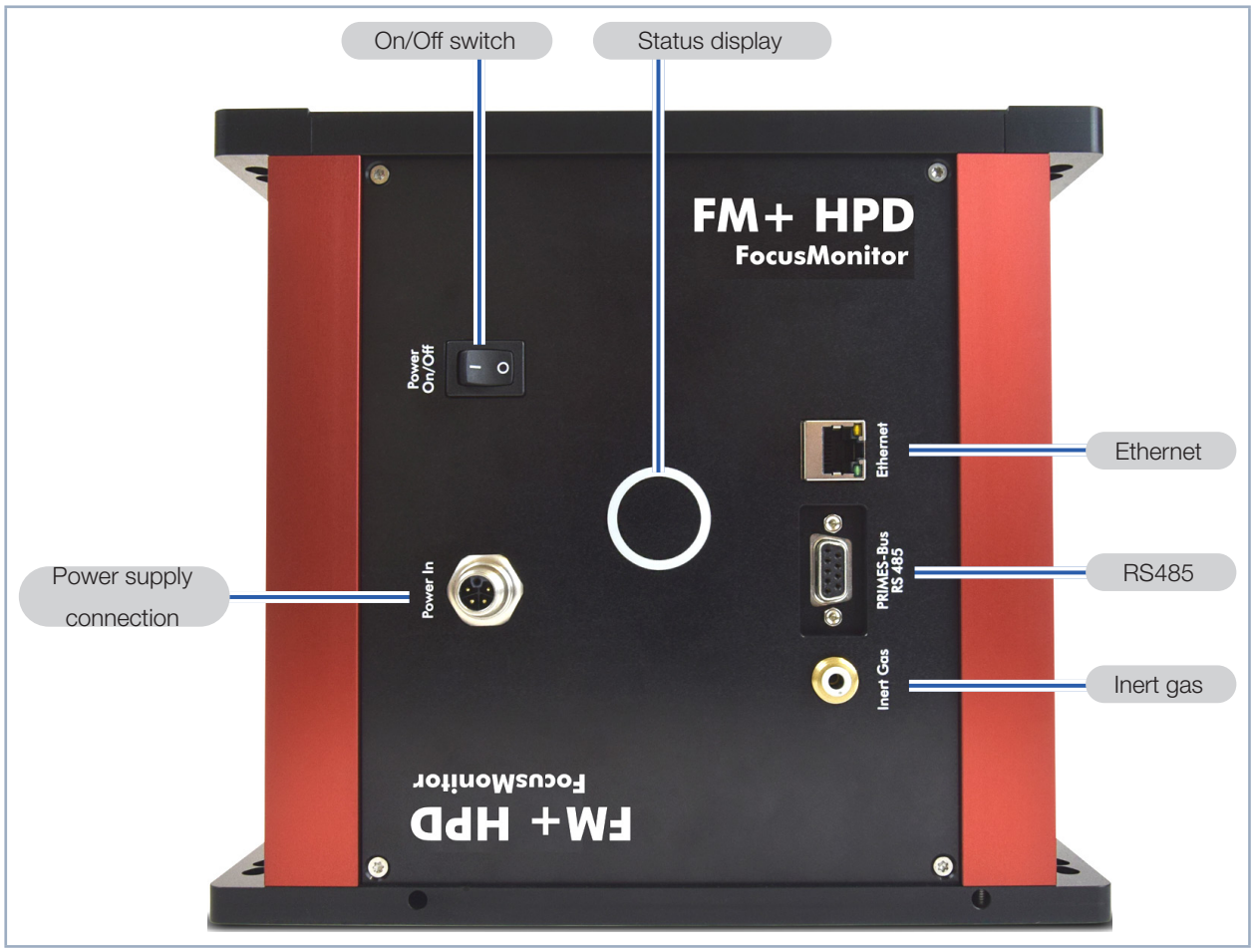
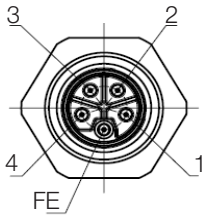


Fig. 8.1: FocusMonitor FM+ HPD connections

8.2 Power supply

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

Only use the provided Primes power supply and connection lines

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: Pin assignment for the power supply

8.3 Ethernet

Data between the FM+ and PC is transmitted via Ethernet. Connect the FM+ to the PC via a crossover cable or to the network via a patch cable.

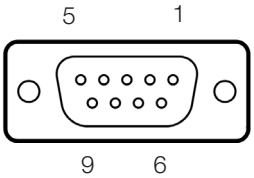
8.4 PRIMES Bus-RS485

A PRIMES laser power meter can be connected to the FM+ via the PRIMES bus (RS485 interface).

The signal from the laser power meter is transmitted through the FM+ to the PC via the Ethernet interface. The additional laser power meter is powered by the power supply of the FM+.

Suitable PRIMES laser power meters can be found in chapter 7.2.6 „Connection of the FocusMonitor FM+ HPD and a laser power measurement device“ on page 23.

8.4.1 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: Pin assignment of the D-sub socket, PRIMES bus

8.5 Inert gas connection

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.

To protect the FS³ from dust particles and contamination, the FS³ can be flushed with inert gas or cleaned compressed air via the inert gas connection.

Connection is established through a 4 mm plug

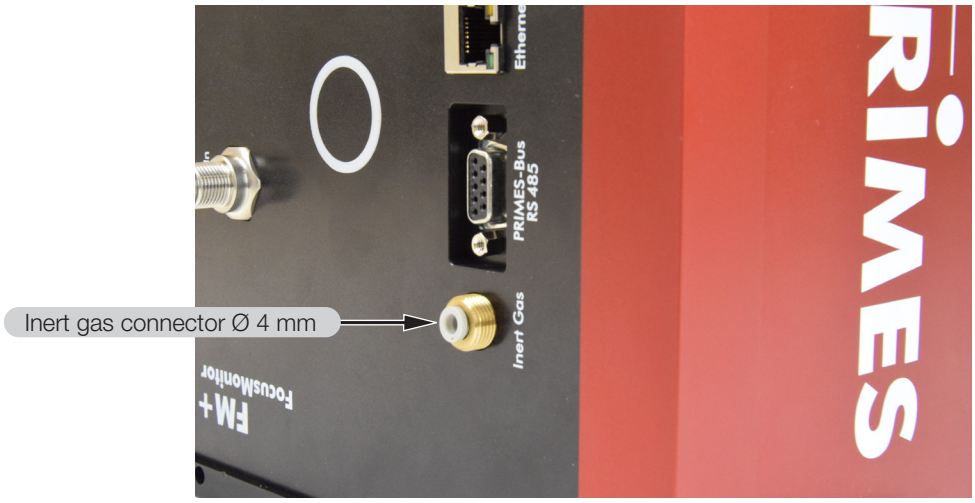


Fig. 8.2: Inert gas connection

9 Measuring with the LaserDiagnosticsSoftware LDS

This chapter describes measurements with the LDS. For a detailed description of the software installation, file management and evaluation of the measured data, please refer to the separate operating manual “LDS”.

9.1 Safety instructions

DANGER

Serious eye or skin injury due to laser radiation

The device measures direct laser radiation, but does not emit any radiation itself. However, during the measurement the laser beam is reflected at the rotating FS³. This produces scattered or directed reflection of the laser beam (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+ HPD must be maintained even when wearing safety goggles and safety clothing.

DANGER

Serious eye or skin injury due to glass splinters

A mechanical damage to the FS³ can destroy it during measurement operation. Due to the high speed of the FS³, ejected glass splinters can lead to severe injuries of the skin, the eyes or even to a loss of vision.

- ▶ Do not operate the device without the curved touch protection in front of the FS³.
- ▶ Protect yourself by placing an appropriate shielding wall between the device and the area where people are present.

DANGER

Serious eye or skin injury due to laser radiation

If the device is moved from its aligned 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+ HPD is being operated, the irradiation must be fully absorbed behind the measurement zone. Fire bricks or other partly-absorbing surfaces are not suitable.

- ▶ Use a suitable absorber. PRIMES offers, depending on the application, suitable laser power meters for permanent absorption, e.g. 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 FS³ of the FocusMonitor FM+ HPD rotates at high rotational speed during the measuring operation. Even after the motor has been turned off, the FS³ will continue to rotate for a certain amount of time.

- ▶ Do not reach into or hold any objects into the inlet aperture of the device.
- ▶ After the motor has been turned off, wait until the FS³ comes to a complete stop.

CAUTION

Danger of crushing in the travel range of the carriers

The hand or fingers can be crushed in the travel range of the horizontal and vertical carrier.

- ▶ Do not reach into the travel range of the horizontal and vertical carriers.
- ▶ Observe that the horizontal and vertical carrier automatically move to the park position after the device has been switched off and on again.

9.2 Preparing measurement readiness

9.2.1 Clean FS³ before each measurement

⚠ CAUTION

Burns due to hot components

Parts near the FS³ can be hot due to scattered radiation.

- ▶ Do not clean the FS³ directly after a measurement.
- ▶ Let the device cool down for an adequate period of time. The cooling time varies depending on the laser power and the irradiation time.

NOTICE

Damage/Destruction of the FS³

Touching the FS³ can lead to burn-in by the laser radiation at the points of contact. Burn-in lead to damage or cracking of the FS³.

- ▶ Do not touch the FS³.
- ▶ When cleaning the FS³ wear powder-free latex gloves.

NOTICE

Damage/destruction of the dust protection and the FS³

If the dust protection is irradiated with the laser, the dust protection and the underlying FS³ will be destroyed.

- ▶ Remove the dust protection before measuring.

The FS³ must be cleaned before each measurement.

1. Remove the dust cover as described in Kapitel 7.2.3 on page 19 .
2. Put on powder-free latex gloves.
3. Carefully clean the FS³ with isopropanol when cooled down (observe the safety instructions of the manufacturer) and lens cleaning cloth.

Do you need help?

You can find a tutorial video under the following link:

www.primes.de/en/support/downloads/tutorialvideos/fmplus-hpd.html

NEED HELP?

www.primes.de/de/support/downloads/tutorialvideos/fmplus-hpd.html

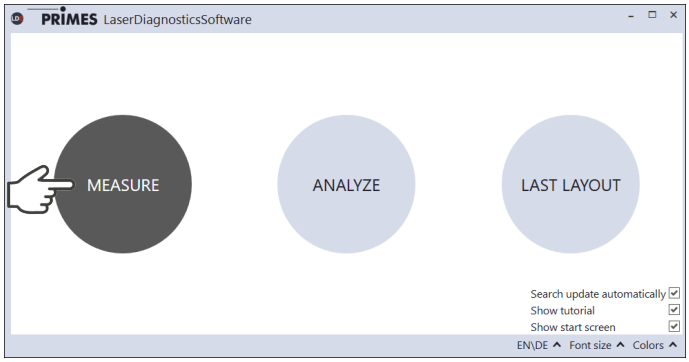
9.3 Connect/disconnect the device with the LDS

9.3.1 Switch on the device and connect it to the LDS

1. Switch on the Power On/Off-switch.
2. Start the LDS by double-clicking on the program icon LDS in the start menu group or on the desktop icon.

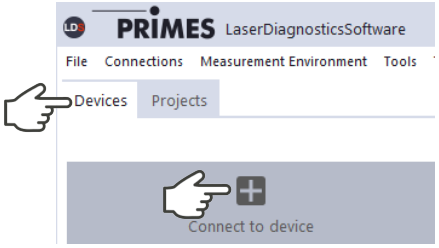
The start screen appears.

3. Select the operating mode ***Measure***.



If the ***Show start screen*** option is disabled or the window ***Connections*** is closed:

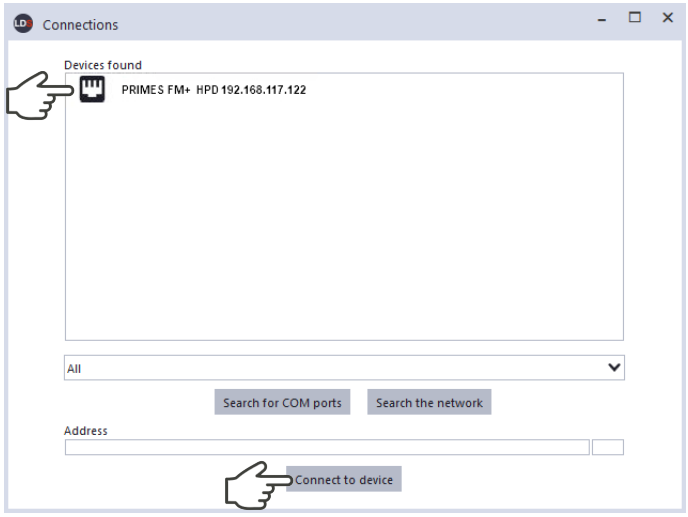
▶ Click on the ***Devices*** tab and then on the ***+ Connect to device*** button.



The ***Connections*** window appears.

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

If the device still does not appear see chapter 10.2, „Connection Error with the LDS“, on page 64



9.3.2 Change IP address of a connected device

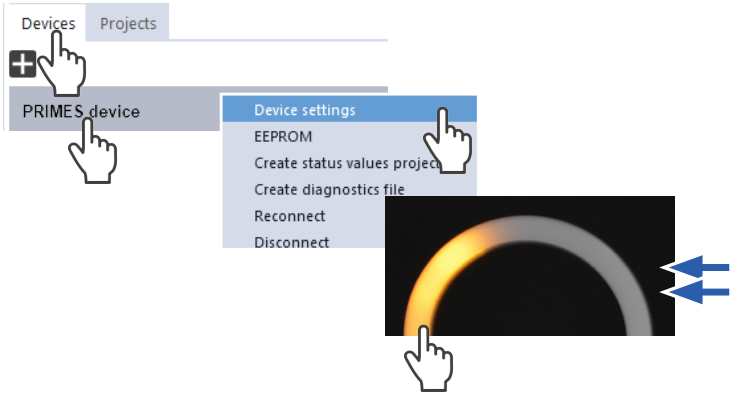
A static IP address is stored within the device and the function ***Use DHCP*** is activated. When establishing a connection, the device will first wait to be assigned a suitable IP address via DHCP. If this proves unsuccessful, it will revert to the factory static IP address.

If ***Use DHCP*** is disabled, the device will use the static IP address. As a result, the connection can be established faster.

For a connected device, both the IP address and the activation of DHCP can be changed.

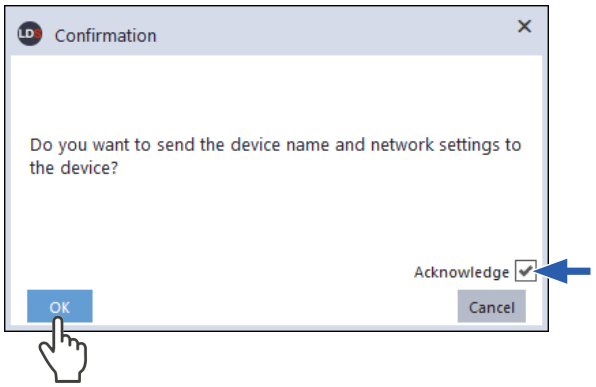
Change the IP address of a device as follows:

1. Click on the ***Devices*** tab.
2. Right-click on the device and select the ***Device settings*** menu point.
3. Enter the desired IP address in the ***Static IP address*** input field.
4. Deactivate ***Use DHCP***.
5. Confirm the entry with ***OK***.



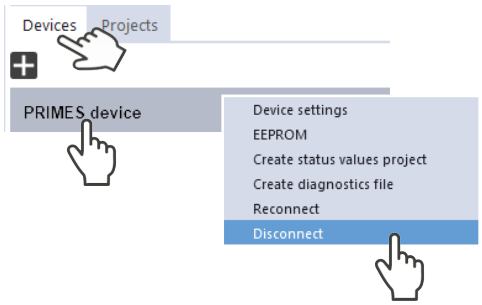
The ***Confirmation*** window appears.

6. In the ***Confirmation*** window, place a check mark at ***Acknowledge*** and click ***OK***.
7. Power cycle the device.



9.3.3 Disconnect device from the LDS and switch off

1. Click on the ***Devices*** tab.
2. Right-click on the device and select the ***Disconnect*** menu point.



👁 The ***Close connection*** window appears.

3. Choose one of the options offered:

▶ Confirm by clicking the ***OK*** button. Select this option to make the device transportable or storable.

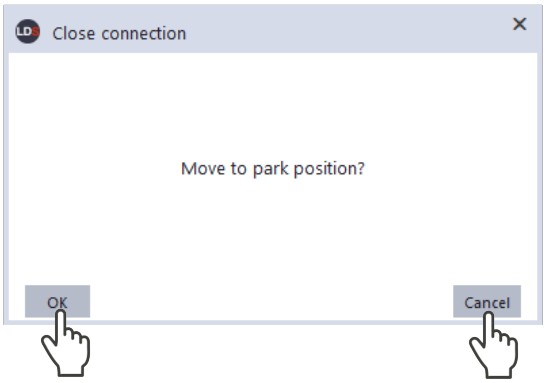
➔ The horizontal and vertical carrierr move to the park position (FM+).

➔ The device is disconnected from the LDS.

▶ Click on the ***Cancel*** button.

➔ The horizontal and vertical carrier remain in the current position (FM+).

➔ The device is disconnected from the LDS.



4. Switch off the device.
5. If applicable, disconnect the electrical connections.

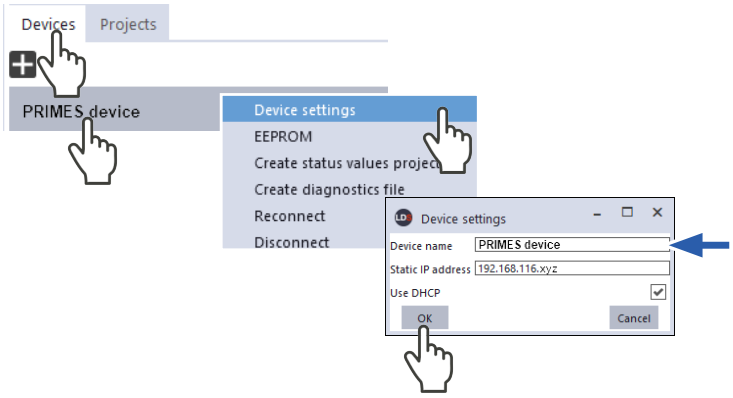
9.4 General information about working with the LDS

This chapter contains general information about the LDS, irrespective of the respective measuring task. Read this general information before turning to the following chapters on the various measurement modes.

9.4.1 Enter user-defined device name

If you want to assign a user-defined device name to a device, proceed as follows:

1. Click on the ***Devices*** tab.
2. Right-click on the device and select the ***Device settings*** menu point.
3. Enter the desired device name in the ***Device name*** input field (max. 18 characters).
4. In the ***Device settings*** window, confirm the entry with ***OK***.

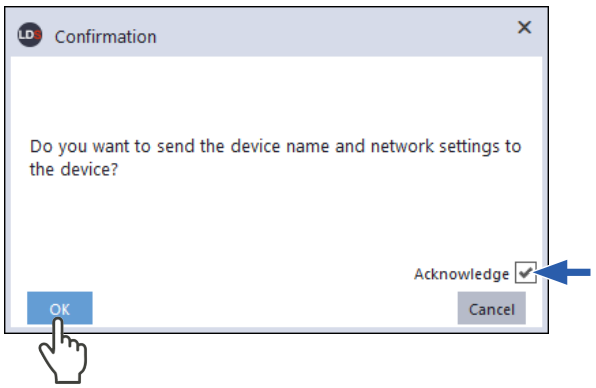


The ***Confirmation*** window appears.

5. Place a check mark at ***Acknowledge*** and click ***OK***.
6. Switch the device off and on again.

→ The device name is displayed in the ***Connections*** window.

→ After connecting, the device name is displayed in the ***Devices*** tab.

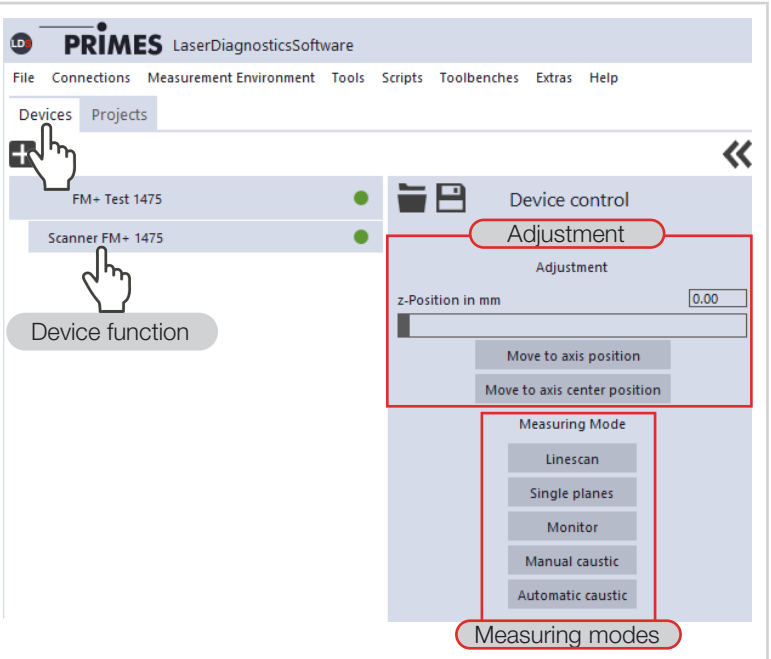


9.4.2 Open the device control menu

1. Click on the ***Devices*** tab.
2. Select the device and click on the device function ***Scanner*** below the device name.

The ***Device control*** menu with the following sections opens.

- ***Adjustment*** (see chapter 9.4.3 on page 34)
- ***Measuring modes*** (see chapter 9.4.4 on page 35)



9.4.3 Move vertical carrier for setup

The ***Adjustment*** area of the ***Device control*** menu offers various options for moving the vertical carrier. The vertical carrier moves from the zero position (z=0) to the entered distance.

The distance of the pinhole in the measuring tip to the horizontal carriage can be taken from 9.1 on page 27

Option	Explanation
z-Position in mm	▶ Enter the desired z-position in the input field or use the carrierr.
Move to axis position	▶ Click this button to move the vertical carrier to the z position specified in the ***z-Position in mm*** field. Note that this does not have to be the maximum traversing range of your device. If a locked area of the z-axis was stored in the EEPROM during a previous use of the device, then this locked area is active.
Move to axis center position	▶ Click this button to move the vertical carrier to the center position of the (unlocked) z-axis traversing range. Note that this does not have to be the maximum traversing range of your device. If a locked area of the z-axis was stored in the EEPROM during a previous use of the device, then this locked area is active. The vertical carrier then moves to the center position of the unlocked range.

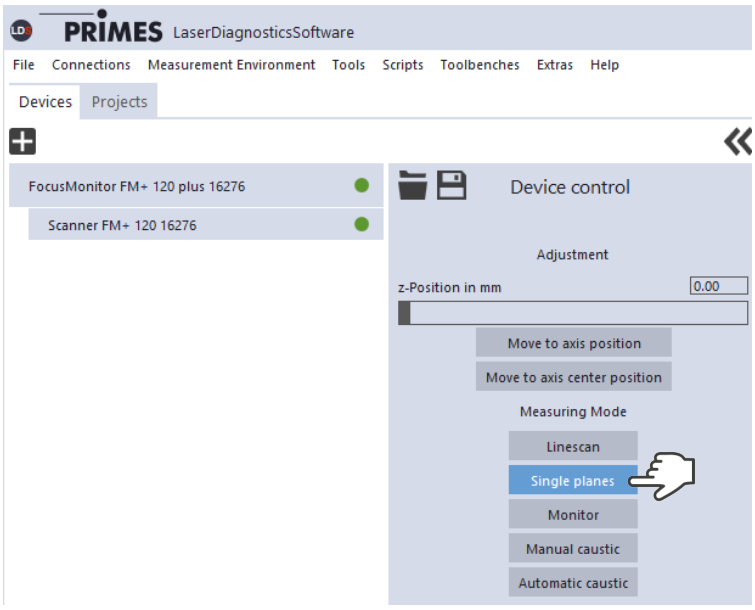
Tab. 9.1: Options in the ***Adjustment*** area of the ***Device control*** menu

9.4.4 Open a measuring mode

The desired measuring mode is selected in the ***Device control*** menu. The following measuring modes are available:

- ***Linescan*** (see chapter 9.7, „Linescan“, on page 45)
- ***Single plane*** (see chapter 9.8, „Single planes“, on page 48)
- ***Monitor*** (see chapter 9.9, „Monitor“, on page 53)
- ***Manual caustic*** (see chapter 9.10, „Manual Caustic“, on page 56)
- ***Automatic caustic*** (see chapter 9.11, „Automatic Caustic“, on page 58)

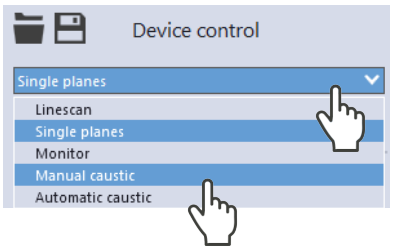
▶ After opening the ***Device control*** menu, click the button of the desired measuring mode, for example ***Single planes***.



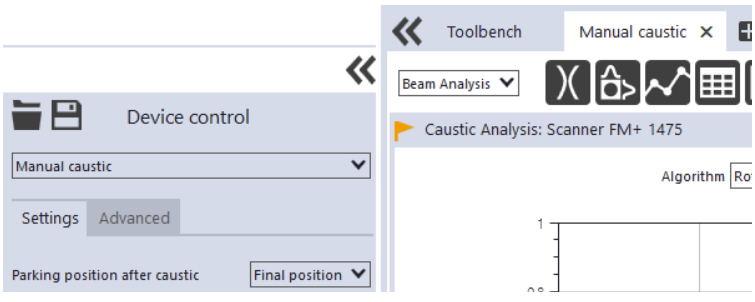
A drop-down list for changing the measuring mode appears in the upper area of the ***Device control*** menu.

Change measuring mode:

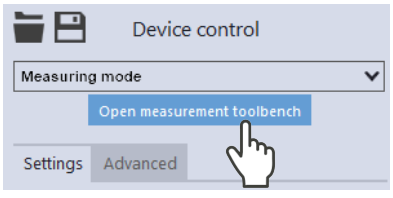
1. Click on the button to open the drop-down list.
2. Click on the measurement mode you want to switch to.



After selecting the measuring mode, the corresponding toolbench is opened.



If the toolbench has been closed, re-open it by clicking the ***Open measurement toolbench*** button.



9.4.5 Enter parameters and activate

When configuring a measurement mode, please note that some parameters are also transferred to other measurement modes. If, for example, parameter entries are made in ***Single planes*** measuring mode, these are automatically transferred to all other measurement modes.

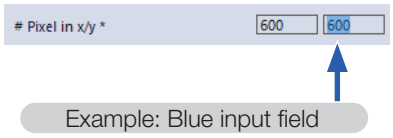
Transfer an entered parameter value with the Enter key:

1. Enter the desired value in the input field.

👁 The background color of the input field changes to blue.

2. Confirm the entry by pressing the Enter key.

👁 The field returns to its original background color.



9.4.6 Saving options

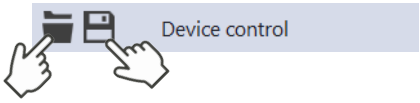
The LDS offers (up to) three different options for saving. They differ by the storage location and the selection of the data to be saved.

When saving/loading a configuration, note that the command is called in a certain measurement mode, but the saved/loaded data set also includes the settings of the other measurement modes.

Save data with asterisk (*) on the PC:

All data marked with an asterisk in the ***Device control*** menu can be saved to a preset file with the extension ***.pre*** on the PC.

- ▶ To save a configuration, click on the icon 💾.
- ▶ To load a configuration click on the icon 📂.

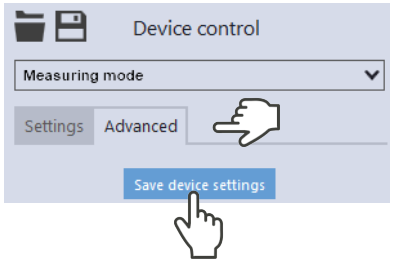


Save data with asrerisk (*) in the EEPROM of the device:

All options marked with an asterisk in the ***Device control*** menu can be saved in the EEPROM in the device.

In this case, the settings will be retained even if the device is switched off or disconnected from the power supply.

1. Click on the ***Advanced*** tab.
2. Click on the ***Save device settings*** button.



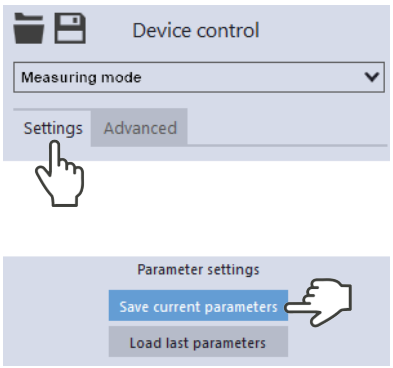
Save all settings in the LDS:

With these buttons you can save or load all settings of the ***Device control*** menu. The storage is made device-related in the local installation of the LDS.

1. Click on the ***Settings*** tab.
2. Use one of the following options:

▶ Click the ***Save current parameters*** button to save the settings of the connected device.

▶ Click on the ***Load last parameters*** button to load the last saved settings.



9.5 Settings applicable to the various measurement modes

9.5.1 Define locked area

The ***Locked area*** in the ***Device control > Advanced*** menu enables a spatial restriction of the measuring range in y- and z-direction. The defined locked area is not approached by the horizontal and vertical carriers. A locked area can be set in the individual measuring modes and is adopted in all measuring modes.

For standard installation

The position z=0 and y=0 defines the the lower left corner of the locked area as resting position.

The z-coordinate of the point P1 cannot be changed.

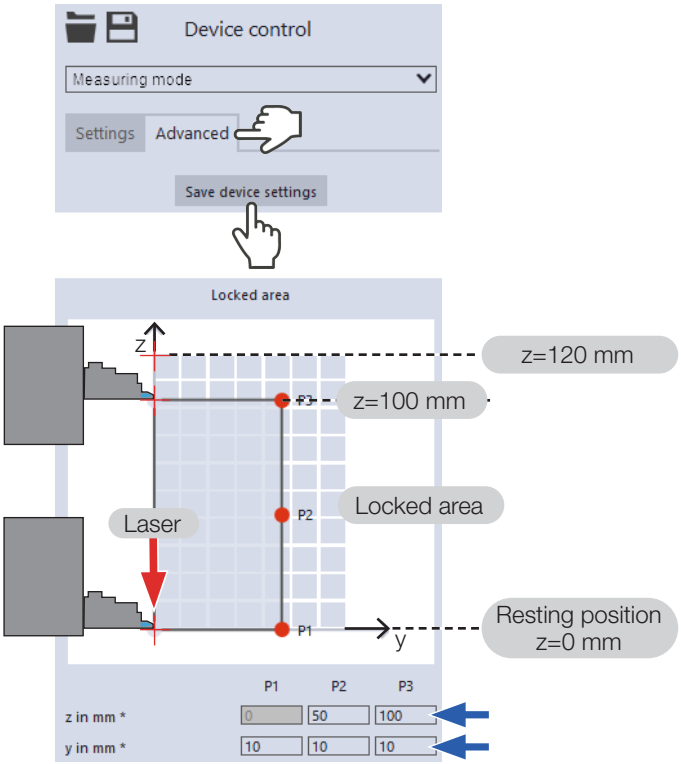
1. After opening the ***Device Control*** menu, click the ***Advanced*** button.
2. Use one of the following options:

▶ Enter the locked area in the P1, P2, P3 input fields.

▶ Press the left mouse button and drag the red dots.

3. Press the ***Save device settings*** button.

➔ The locked area is saved and applied to all measurement modes.



9.5.2 Move axes

Move axes in the ***Device Control > Advanced*** menu contains options for moving the vertical and horizontal carrier. ***Move axes*** can be set in the individual measuring modes and is adopted in all measuring modes.

The distance of the pinhole in the measuring tip to the horizontal carrier is shown in Fig. 9.1 on page 62

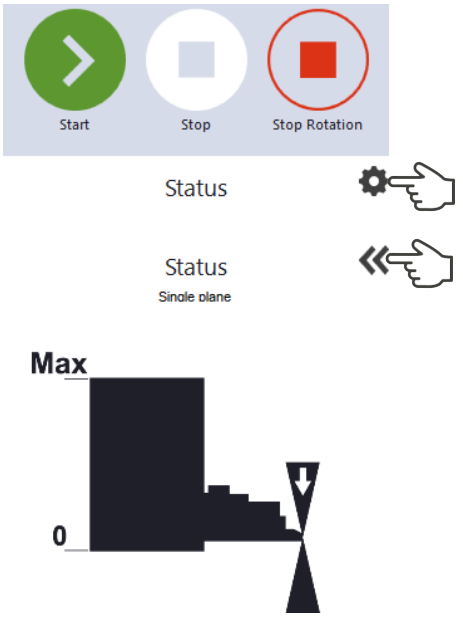
Option	Explanation
y-Position in mm	▶ Enter the desired y-position in the input field or use the carrierr.
Move to y-position	▶ Click this button to move the horitontal carrier to the y-position specified in the ***y-Position in mm*** field. Note that this does not have to be the maximum traversing range of your device. If a locked area of the z-axis was stored in the EEPROM during a previous use of the device, then this locked area is active.
z-Position in mm	▶ Enter the desired z-position in the input field or use the carrierr.
Move to z-position	▶ Click this button to move the vertical carrier to the z-position specified in the ***z-Position in mm*** field. Note that this does not have to be the maximum traversing range of your device. If a locked area of the z-axis was stored in the EEPROM during a previous use of the device, then this locked area is active.
Move to focus of selected caustic	1. Select a caustic in the project tree (see separate operating manual of the LaserDiagnosticsSoftware LDS). 2. Click this button to move the vertical carrier to the z-position of the focus position. Make sure that the focus is not in the locking range of the z-axis. If a locked area of the z-axis was stored in the EEPROM during a previous use of the device, then this locked area is active and the selected caustic cannot be approached.

Tab. 9.2: Options in the ***Move axes*** area of the ***Device control > Advanced*** menu

9.5.3 Display Device Alignment

Clicking on the gear icon ⚙ displays the device alignment

Clicking on the arrow symbol << redisplays the previous view..



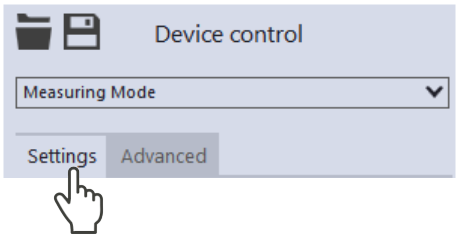
9.6 Device control

9.6.1 Settings

The options listed in alphabetical order are not available in all measuring modes.

1. Click on the ***Settings*** tab.
2. Enter the options according to the explanations in the following table.

▶ Data with (*) can be saved, see chapter 9.4.6, „Saving options“, on page 36.



Option	Explanation
Save current parameters	▶ Click this button to save all current settings of the connected device.
***Number of planes** **	▶ Enter the number of planes to be measured.
***Number of measurements** **	▶ Enter the desired number of single plane measurements of the time series.
autom. Measurement window	If this option is enabled, then the measurement window size will be set automatically. ▶ Set the check mark to enable the option.
autom. Gain	When using a CO_2 detector, this option is not available and will not be displayed. If this option is enabled, the gain is set automatically. ▶ Set the check mark to enable the option.

Window size in mm	If the ***autom. Measurement window*** option is disabled, the size of the measurement window can be set manually. Use one of the following options: ▶ Enter the length and width in the corresponding input fields. ▶ Position the mouse pointer anywhere within the measurement range and drag while holding down the left mouse button. Keep the mouse button pressed until the measurement window meets your requirements.
Interval between measurements in s*	▶ Enter the pause between the single plane measurements of the time series. This is the time gap between the end of one measurement and the start of the next.
Caustic proposal (z-range in mm)	After a completed caustic measurement, a z-range is displayed in these fields, whose limits z1/z2 have a distance of ± 3 Rayleigh lengths to the determined beam focus. This z-range is optimized according to Primes quality criteria. ▶ Click on the Apply button to accept the caustic proposal for further measurements.
Load last parameters	▶ Click this button to load the last saved device configuration.
Line center in mm	Use one of the following options to adjust the position of the measuring line: ▶ Enter the x-/y-position of the line center in the corresponding input fields. ▶ Position the mouse pointer within the measurement window. Then drag while holding down the right mouse button.
Line width in mm	Use one of the following options to adjust the line width (length) and position: ▶ Enter the width (length) of the line. ▶ Position the mouse pointer at any point within the measurement area and drag while holding down the left mouse button. Keep the mouse button pressed until the length of the measuring line meets your requirements.
Manual z-Position in mm	This option defines the position of the next measurement on the z-axis chapter 9.8.3, „Measure manual caustics with the single plane measurement mode“, on page 50). 1. Set the check mark at ***Deactivate z-axis***. 2. Enter the ***Manual z-position in mm***.
Measurement duratin in s	▶ Enter the duration of the measurement in s.
Reset measurement window	▶ Click this button to maximize the measurement window and simultaneously center it in the measurement range.
nominal Power P in W*	To calculate the power density, the laser power used must be entered. Otherwise, the measured amplitudes are given directly in counts. ▶ Enter the nominal laser power used during measurement.
Optimized measurement settings	If this option is activated, then the duration of the measurement is shortened.Fewer process steps are required because the initial settings for a plane measurement are taken from the settings of the previous plane measurement. Note, however, that ray artifacts may not be sufficiently detected in the individual plane measurements due to the inheritance of the settings. ▶ Set the check mark to enable the option.

Parameter settings	All settings in the ***Device control*** menu can be individually saved for each device. The saving location is the local installation of the LDS. This and other options for saving/loading configurations are described in chapter 9.4.6, „Saving options“, on page 36
Parking position after caustic	▶ From the drop-down list, select the parking position to which the measuring head will move after the caustic measurement. You have the following options: • ***Focus:*** The measuring head is moved back to the position of the determined beam focus. • ***Start position:*** The measuring head is moved back to the start position. • ***End position:*** The measuring head remains in the end position. The selected position is also the start position for the precaustic measurement of the next measurement (unless you enter a different value in the z position in mm field).
# Pixel in x	The number of pixels determines the resolution of the measurement. Use one of the following options: ▶ Enter a value in the input field. ▶ Use the carrierr below the input field.
Position in mm	Use one of the following options to adjust the position of the measurement window: ▶ Enter the x-/y-position in the corresponding input fields. ▶ Position the mouse pointer within the measurement window. Then drag while holding down the right mouse button.
Find beam	This option enables an automatic beam search with an automated measuring window size and measurement. The laser beam is automatically searched for in the entire measuring range. Measurement window size and gain are set automatically. The measured plane is then displayed in the graphic display. ▶ Click on the button to start the beam search. Note that the determined measurement data will not be saved in the project tree of the ***Projects*** tab.
Gain in dB	When using a CO_2 detector, this option is not available and will not be displayed. If the ***autom. Gain*** option is disabled, the gain can be set manually. The option can be used to control the sensitivity of the detector. Use one of the following options: ▶ Enter a value in the input field. ▶ Use the carrierr below the input field.
Time series	A time series consists of several single plane measurements with the same settings.
z-Axis position (z1/z2) in mm *	By entering the upper and lower limits of the precaustic, the range is defined in which the precaustic is measured. This function is particularly useful for measuring beams with high divergence. This option is used to determine the z-range in which the measurement is to be performed. ▶ Enter the lower limit z1 in the left field and the upper limit z2 in the right field. ▶ Alternatively, use the carrierrs.

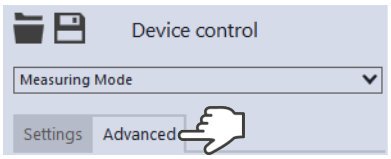
Deactivate z-axis	With this option the z-axis of the device is deactivated. This setting is used when the laser system moves to the position of the next measurement. Enabling the option activates the ***Manual z-position in mm*** input field. ▶ Set the check mark to enable the option.
z-Position in mm *	Use one of the following options to set the desired z-position of the plane to be measured: ▶ Enter a value in the input field. ▶ Use the carrierr on the left side of the graphic display.
z-step size in mm	This option automatically defines the position of the next measurement on the z-axis see chapter 9.8.3, „Measure manual caustics with the single plane measurement mode“, on page 50) ▶ Enter the z-step size in mm.

9.6.2 Advanced

The options listed in alphabetical order are not available in all measuring modes.

1. Click on the ***Advanced*** tab.
2. Enter the options according to the explanations in the following table.

▶ Data with (*) can be saved, see chapter 9.4.6, „Saving options“, on page 36.



Option	Explanation
Move axes	With this option, the vertical and horizontal carriers can be moved in a defined manner. There are 3 options to choose from: • Move to y position • Move to z position • Move to the focus of the selected caustic Use one of the following options: ▶ Enter a value in the input field. Use the carrierr below the input field. This option is described in chapter 7.2.2, „Installation position“, on page 18 beschrieben.
***Number of measurements** *	▶ Enter the desired number of single plane measurements of the time series.
***Number of averaged planes** *	With the default setting of ***1*** in the input field, no averaging takes place. ▶ Enter the number of plane measurements >***1*** for averaging

Option	Explanation
***Arithmetic Average** *	The default algorithm for averaging the plane measurements is ***Arithmetic Average***. Averaging over several measurements can be useful, for example, when measuring a laser with significant power fluctuations. ▶ Select an algorithm from the drop-down list: • ***Arithmetic Average***: The measured values for each pixel are added together and divided by the number of planes. • ***Max. intensity per pixel***: The values from all the measurements are compared for each pixel and only the maximum value for each one is displayed. • ***Max. Lines***: The values from all the measurements are compared for each line (meaning the line issuing from the measuring device in the x-direction for example) and only the maximum value for each one is displayed.
***Focal length of focusing optics in mm** *	If several planes of a caustic have been measured, the caustic fit and the entered focal length are used to calculate the raw beam diameter on the focusing optics. ▶ Enter the focal length used by the focusing optics of the laser system.
Save device settings	All options marked with an asterisk in the ***Device control*** menu can be saved in the EEPROM of the device. These and other options for saving/loading configurations are described in chapter 9.4.6 on page 36.
***Calibrated wavelength(s) in nm** *	The “calibrated wavelength” is the wavelength at which the device has been validated. This is stored in the device and is displayed in the LDS.
Measuring tip	**Documentation of the measuring tip used** With these options, the specifications of the measuring tip used can be entered into the LDS for documentation of the measurements performed. This option is described in chapter , „Inputs for the Used Measuring Tip“, on page 79
***nominal Power P in W** *	To calculate the power density, the laser power used must be entered. Otherwise, the measured amplitudes are given directly in counts. ▶ Enter the nominal laser power used during measurement.
***# Pixel in x/y** *	The number of pixels determines the resolution of the measurement. ▶ Enter the resolution in x-/y-direction in the corresponding input fields.
Locked area	With this option, a spatial restriction of the measuring range can be defined in y- and z-direction. The defined restricted area is not approached by the horizontal and vertical carrier. Use one of the following options: ▶ Enter the locked area in the P1, P2, P3 input fields. ▶ Press the left mouse button and drag the red dots. This option is described in chapter 15, „Dimensions“, on page 73

Option	Explanation
***Used wavelength in nm** *	To calculate the beam quality factor M^2, the used wavelength must be entered. Depending on the display in the option ***Calibrated wavelength(s) in nm,*** the used wavelength can be entered in a defined range. For example, with a „calibrated wavelength“ of 1 064 nm, the used wavelength can be entered from 1 000 - 1 100 nm. Use one of the following options to set the wavelength of the laser used: ▶ Enter a value in the input field. ▶ Use the carrierr below the input field.
Pre-Caustic	The optimal measurement parameters, such as measurement window position, measurement window size, integration time and the z-range (measurement range along the beam propagation), are determined automatically
z-Axis position (z1/z2) in mm *	By entering the upper and lower limits of the precaustic, the range is defined in which the precaustic is measured. This function is particularly useful for measuring beams with high divergence. This option is used to determine the z-range in which the measurement is to be performed. ▶ Enter the lower limit z1 in the left field and the upper limit z2 in the right field. ▶ Alternatively, use the carrierrs.

9.7 Linescan

In measuring mode ***Linescan***, the laser beam is measured at a defined position on the y-axis.

The line width, line center and position on the Y-axis are freely adjustable. The FS³ of the FM+ HPD is moved to a fixed y-position.

The line width, line center and position on the y-axis are freely adjustable.

At this position, the FM+ HPD measures the power density on a single measurement path with each rotation of the FS³."

The measurement is carried out over a defined period of time or until it is manually aborted.

9.7.1 Search laser beam automatically

1. Follow the warning messages in chapter 9.1, „Safety instructions", on page 27.
2. Click on the ***Settings*** tab.
3. Enter the position of the measurement on the z-axis in the input field ***z-position in mm***.
4. Switch on the laser.
5. Click on the ***Find beam*** button.

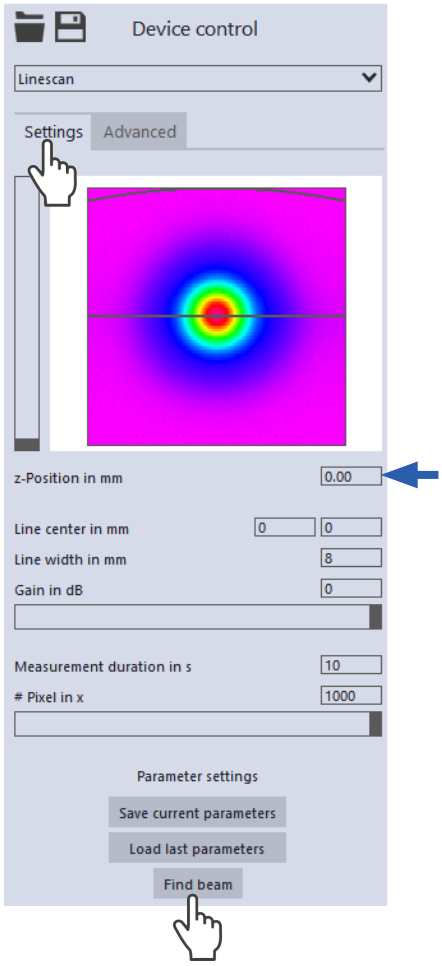
→ The laser beam is automatically searched for in the entire measuring range. The measurement window and gain are set automatically.

If the search is successful, the laser beam is displayed in the graphic representation.

If the beam is not displayed:

- ▶ Check again the correct alignment ofthe device on the x-y plane according to chapter 7.2.4, „Align the device", on page 20.
- ▶ Check the direction of the beam entrance.
- ▶ Adjust the gain.
- ▶ Choose a different z-position.
- ▶ Increase the laser power (step by step).

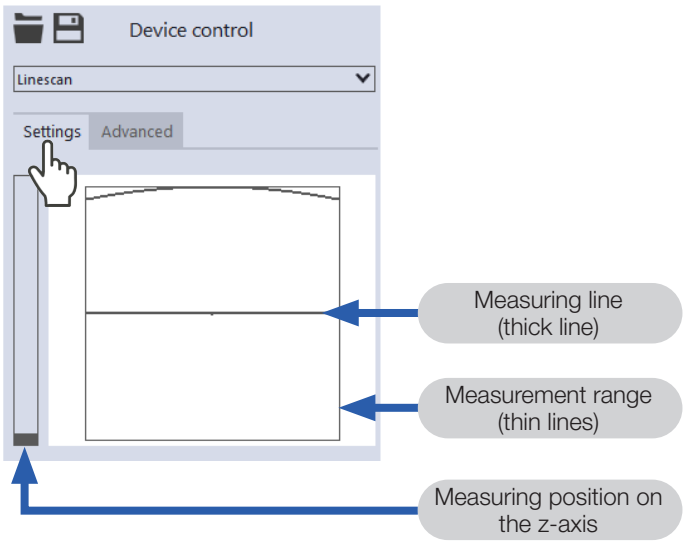
6. If necessary, adjust the measurement window manually according to the following chapter chapter 7.2.3, „Remove/insert the dust protection of the FS³", on page 19.
7. Start the measurement according to chapter 9.7.3, „Start measurement", on page 47



9.7.2 Adjust the measuring line manually

In a window in the upper area of the ***Settings*** tab, the measur line is displayed graphically:

- the entire measurable area (measurement range, thin lines)
- the area to be recorded (measuring line, thick lines)
- after performing a beam find and during the measurements, a false color view of the recorded area
- The measuring position on the z-axis



Create a measurement window:

▶ Enter the line size in the corresponding input fields.

▶ Position the mouse pointer anywhere within the measurement range. Drag while holding down the left mouse button. Keep the mouse button pressed until the measurement line meets your requirements.

Adjust the position of the measuring line:

▶ Enter the x-/y-position in the corresponding input fields.

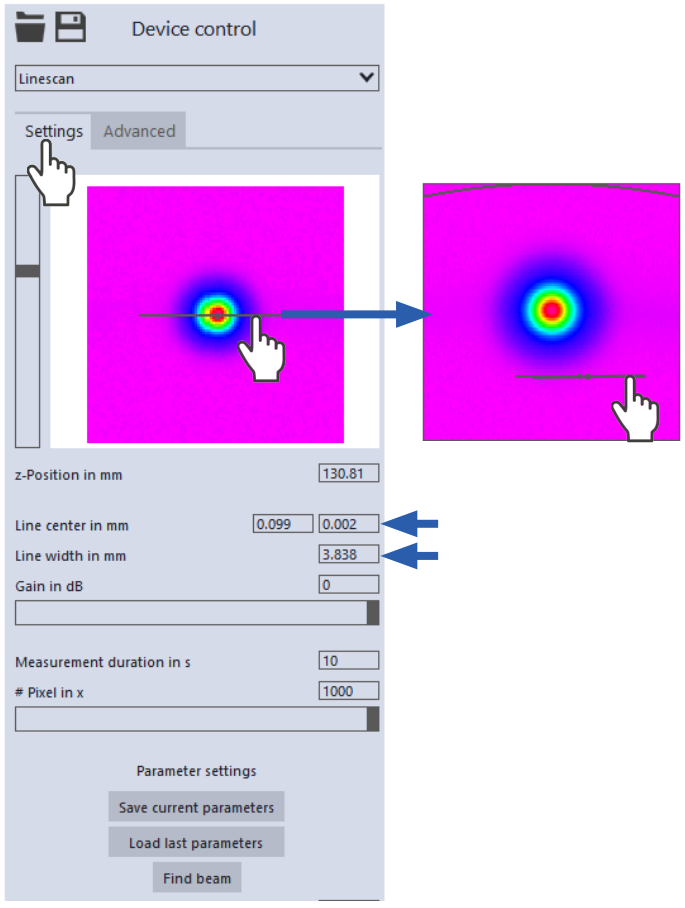
▶ Position the mouse pointer over the measurement line. Drag while holding down the right mouse button.

Zoom with a laser beam displayed:

▶ To zoom to the center of the graphic representation, first move the mouse pointer over the graphic representation until the plus/minus buttons appear.
Then press the buttons.

▶ To zoom in on the position of the mouse pointer, position the mouse pointer anywhere within the graphic representation.
Then turn the mouse wheel.

▶ To zoom to the size of the measuring range. Position the mouse pointer within the measuring range.
Then double-click left.



9.7.3 Start measurement

1. Follow the warning messages in chapter chapter 9.1, „Safety instructions“, on page 27.
2. Click the ***Start*** button.

➔ The measurement begins.

Optional:

▶ Click the ***Stop*** button to abort the measurement.

▶ Click the ***Stop Rotation*** button to stop the rotation of the measuring tip.

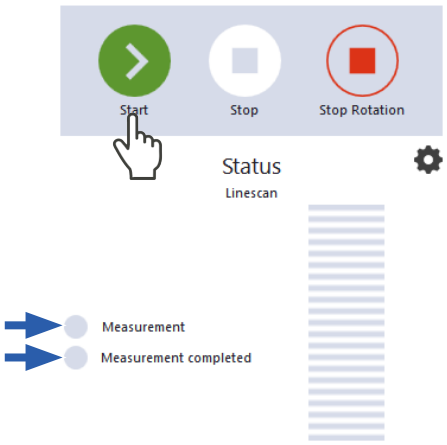
The measurement progress is shown in the following indicators:

Measurement:
While the indicator is rotating, the measurement is performed.

Measurement completed:
After successful measurement, the indicator lights up green.

Averaging (if enabled):
The indication shows the measured planes that are used to average a measured value

3. Switch off the laser after the measurement is completed, unless you want to perform further measurements.



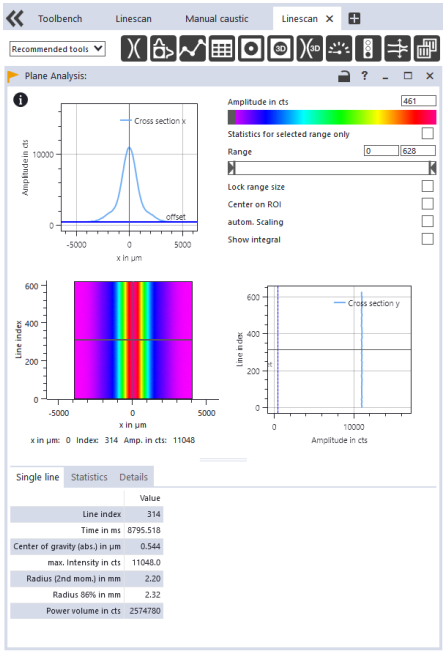
9.7.4 Display measurement results

The measurement results are displayed after the finished measurement in the opened tools.

▶ PRIMES recommens checking the quality of the results after a measurement.

Depending on the results, it may seem necessary to repeat the measurement with improved measurement setup or changed parameters.

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



9.8 Single planes

In ***Single planes*** measuring mode, single planes are measured at selected z-positions. Measurement window size and the gain can be set automatically or determined freely.

The laser beam can be automatically tracked within the entire measurement range.

For a manual caustic measurement, multiple planes can be measured – individually or using a sequential measurement.

A step size along the z-axis can be specified for this purpose (see Kapitel 9.9 on page 53).

9.8.1 Search laser beam automatically

1. Follow the warning messages in chapter chapter 9.1, „Safety instructions“, on page 27.
2. Click on the ***Settings*** tab.
3. Enter the position of the measurement on the z-axis in the input field ***z-position in mm***.
4. Switch on the laser.
5. Click on the ***Find beam*** button.

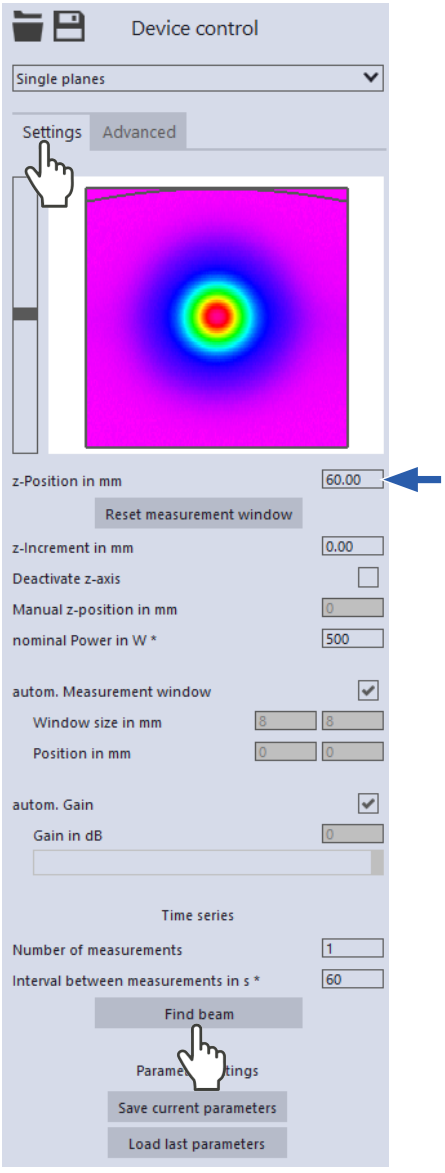
→ The laser beam is automatically searched for in the entire measuring range. The measurement window and gain are set automatically.

👁 If the search is successful, the laser beam is displayed in the graphic representation.

If the beam is not displayed:

- ▶ Check again the correct alignment of the device on the x-y plane according to chapter 7.2.4, „Align the device“, on page 20.
- ▶ Choose a different z-position.
- ▶ Increase the laser power (step by step).

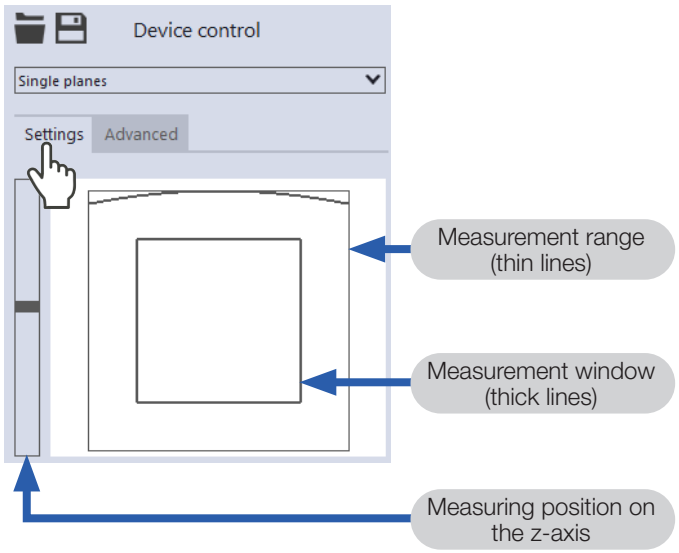
6. If necessary, adjust the measurement window manually according to chapter 9.8.2, „Adjust the measurement window manually“, on page 49
7. Start the measurement according to chapter 9.8.4, „Start measurement“, on page 51.



9.8.2 Adjust the measurement window manually

In a window in the upper area of the ***Settings*** tab, the measurement plane is displayed graphically:

- the entire measurable area (measurement range, thin lines)
- the area to be recorded (measurement window, thick lines)
- after performing a beam find and during the measurements, a false color view of the recorded area
- The measuring position on the z-axis



Create a measurement window:

▶ Enter the window size in the corresponding input fields.

▶ Position the mouse pointer anywhere within the measurement range. Drag while holding down the left mouse button. Keep the mouse button pressed until the measurement window meets your requirements.

Adjust the position of the measurement window:

▶ Enter the x-/y-position in the corresponding input fields.

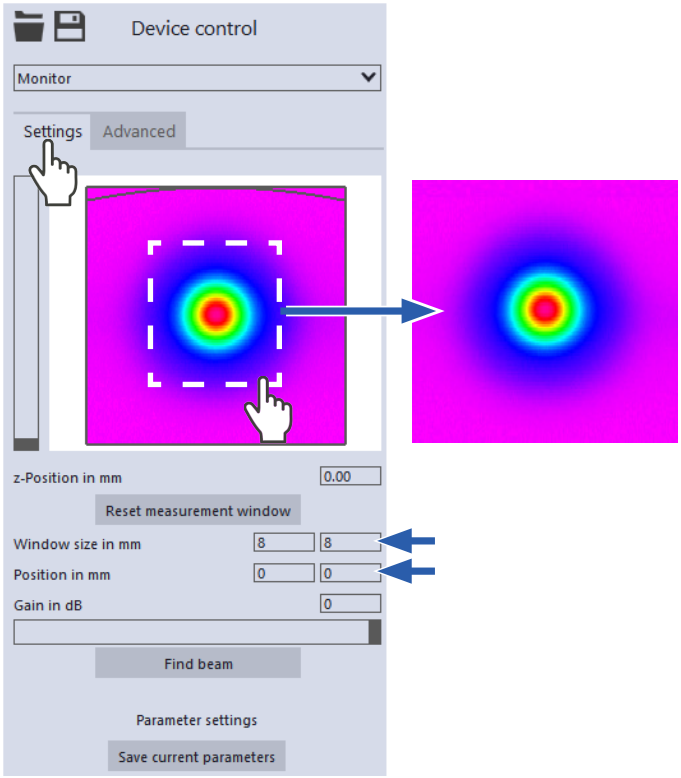
▶ Position the mouse pointer over the measurement window. Drag while holding down the right mouse button.

Zoom with a laser beam displayed:

▶ To zoom to the center of the graphic representation, first move the mouse pointer over the graphic representation until the plus/minus buttons appear. Then press the buttons.

▶ To zoom in on the position of the mouse pointer, position the mouse pointer anywhere within the graphic representation. Then turn the mouse wheel.

▶ To zoom to the size of the measuring range. Position the mouse pointer within the measuring range. Then double-click left.



9.8.3 Measure manual caustics with the single plane measurement mode

To measure a manual caustic several planes can be measured, either individually or by means of a series measurement. Therefor, an increment along the z-axis can be configured. With this procedure, a manual caustic can be measured.

Since the FocusMonitor FMW+ HPD does not have a z-axis, the laser or the device must be moved according to the entered value.

For stigmatic and single astigmatic beams, at least 10 different positions on the z-axis must be measured according to ISO 11146-1. About half of the measurements must be distributed within one Rayleigh length on both sides of the beam waist and about half must be distributed beyond two Rayleigh lengths starting from the beam waist.

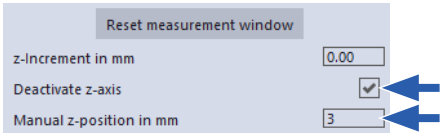
For generally astigmatic and unknown beams, ISO 11146-2 requires measurements to be made at a minimum of 20 uniformly distributed points on the z-axis within a range of at least three times the Rayleigh length both behind and in front of the beam waist.

PRIMES recommends measuring at least 21 planes within ± 3 Rayleigh lengths around the focus. An odd number of measurement planes makes it more likely that the focal plane will be measured.

Single measurement with manual input of the z-position:

This procedure is used when the laser system moves to the position of the next measurement. The z-axis is deactivated for this purpose.

1. Click on the ***Settings*** tab.
2. Set the checkmark at ***Deactivate z-axis***.
3. In the ***z-position in mm*** field, enter the desired position of the next plane to be measured.
4. Start and stop the measurement according to chapter 9.8.4 on page 51.



Single measurements using z-increment spacing:

This procedure works with the z-axis activated and deactivated.

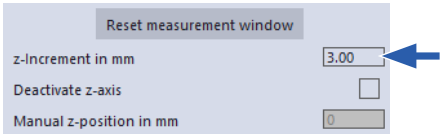
1. Click on the ***Settings*** tab.
2. Enter the spacing for the further measurements in the ***z-Increment in mm*** field.
3. Start the measurement according to chapter 9.8.4 on page 51 and wait until the measurement is completed.

➔ The measured plane is one z-increment away from the previously measured plane.

4. Start a measurement again and wait until the measurement is finished.

➔ The measured plane is one z-increment away from the previously measured plane.

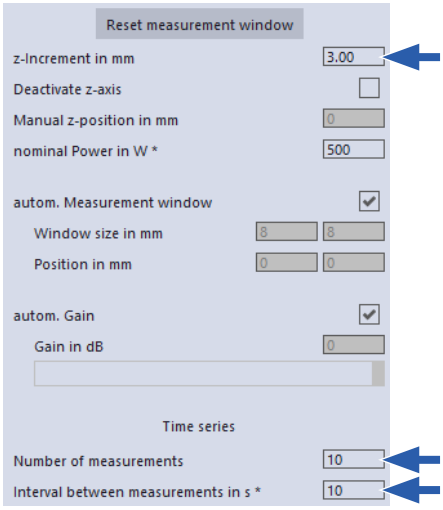
5. Repeat the last step as often as you like.



Series measurement using z-increment spacing:

The combination of the ***Time series*** and ***z-Increment in mm*** options enables measuring a free caustic in one run.

1. Click on the ***Settings*** tab.
2. Enter the spacing for the planes to be measured in the ***z-Increment in mm*** field.
3. In the ***Number of measurements*** and ***Interval between measurements in s*** input fields, enter the number of measurements and the interval.
   The interval is the time between the end of one measurement and the start of the next.
4. Start the series measurement according to 9.8.4 on page 51 and wait until the measurement is finished.



9.8.4 Start measurement

1. Follow the warning messages in chapter chapter 9.1, „Safety instructions“, on page 27.
2. Click the ***Start*** button.

➔ The measurement begins.

Optional:

▶ Click the ***Stop*** button to abort the measurement.

▶ Click the ***Stop Rotation*** button to stop the rotation of the measuring tip.

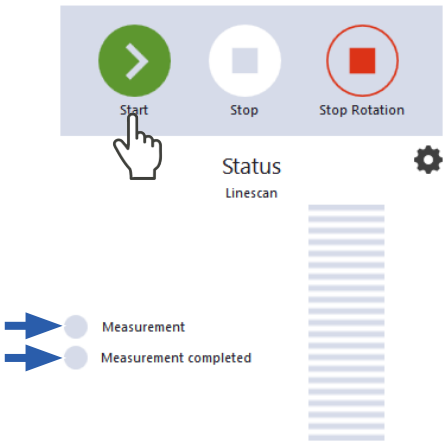
👁 The measurement progress is shown in the following indicators:

Measurement:
While the indicator is rotating, the measurement is performed.

Measurement completed:
After successful measurement, the indicator lights up green.

Averaging (if enabled):
The indication shows the measured planes that are used to average a measured value

3. Switch off the laser after the measurement is completed, unless you want to perform further measurements.



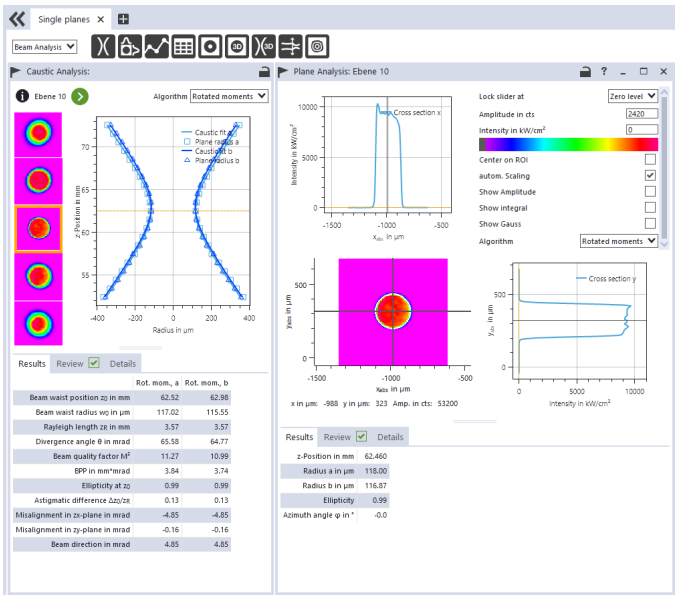
9.8.5 Display measurement results

The measurement results are displayed after the finished measurement in the opened tools.

- PRIMES recommens checking the quality of the results after a measurement.

  Depending on the results, it may seem necessary to repeat the measurement with improved measurement setup or changed parameters.

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



9.9 Monitor

In ***Monitor*** measuring mode, the laser beam is measured continuously at a single plane.

During the measurement, data is continuously read out and displayed in the graphical view. Measurement data are not saved in the project tree of the ***Projects*** tab.

The laser beam can be automatically searched by the software in the entire measurement range. After a successful search the measurement will be run as long as desired.

9.9.1 Search laser beam automatically

1. Follow the warning messages in chapter chapter 9.1, „Safety instructions“, on page 27.
2. Click on the ***Settings*** tab.
3. Enter the position of the measurement on the z-axis in the input field ***z-position in mm***.
4. Switch on the laser.
5. Click on the ***Find beam*** button.

➔ The laser beam is automatically searched for in the entire measuring range. The measurement window and gain are set automatically.

👁 If the search is successful, the laser beam is displayed in the graphic representation.

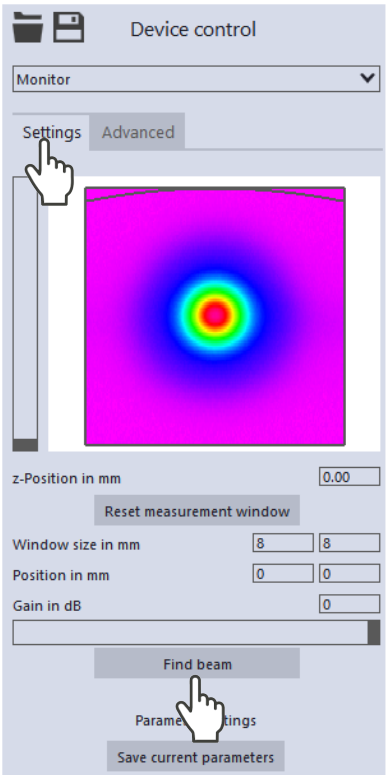
If the beam is not displayed:

▶ Check again the correct alignment of the device on the x-y plane according to chapter 7.2.4, „Align the device“, on page 20.

▶ Choose a different z-position.

▶ Increase the laser power (step by step).

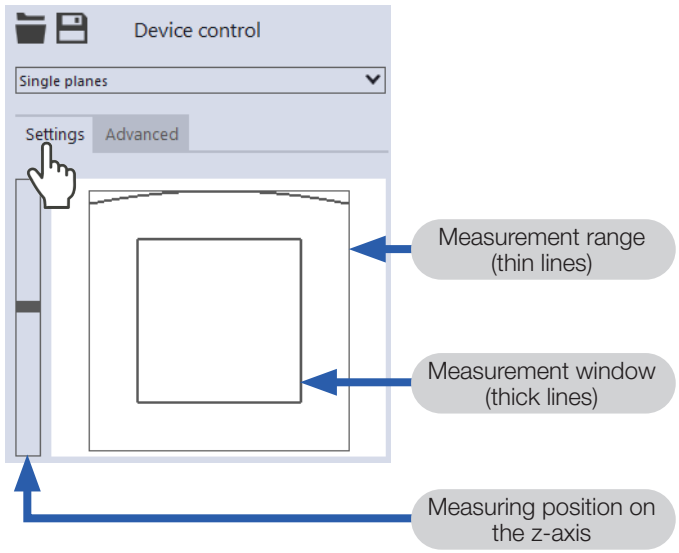
6. If necessary, adjust the measurement window manually according to chapter 9.9.2, „Adjust the measurement window manually“, on page 54
7. Start the measurement according to chapter 9.8.4, „Start measurement“, on page 51.



9.9.2 Adjust the measurement window manually

In a window in the upper area of the ***Settings*** tab, the measurement plane is displayed graphically:

- the entire measurable area (measurement range, thin lines)
- the area to be recorded (measurement window, thick lines)
- after performing a beam find and during the measurements, a false color view of the recorded area
- The measuring position on the z-axis



Create a measurement window:

▶ Enter the window size in the corresponding input fields.

▶ Position the mouse pointer anywhere within the measurement range. Drag while holding down the left mouse button. Keep the mouse button pressed until the measurement window meets your requirements.

Adjust the position of the measurement window:

▶ Enter the x-/y-position in the corresponding input fields.

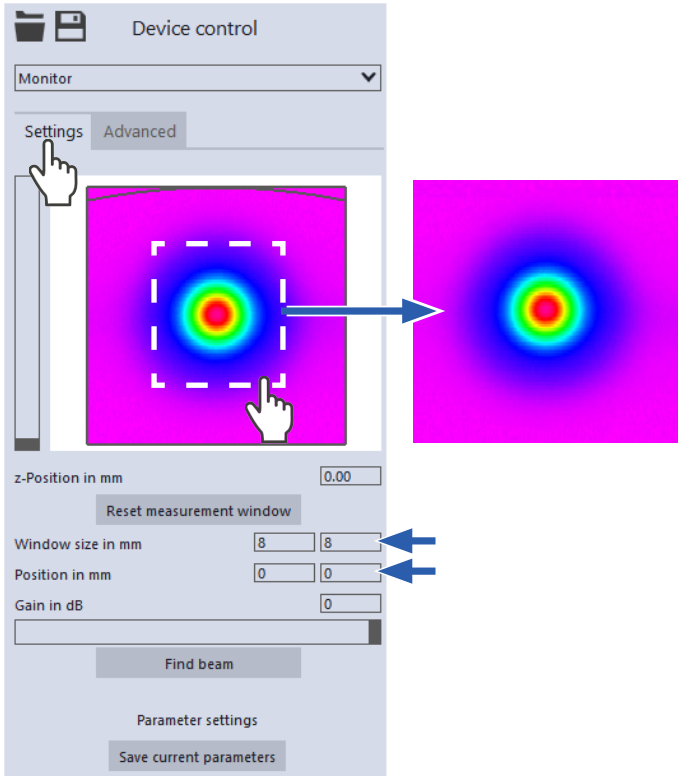
▶ Position the mouse pointer over the measurement window. Drag while holding down the right mouse button.

Zoom with a laser beam displayed:

▶ To zoom to the center of the graphic representation, first move the mouse pointer over the graphic representation until the plus/minus buttons appear. Then press the buttons.

▶ To zoom in on the position of the mouse pointer, position the mouse pointer anywhere within the graphic representation.
Then turn the mouse wheel.

▶ To zoom to the size of the measuring range. Position the mouse pointer within the measuring range.
Then double-click left.



9.9.3 Start measurement

DANGER

Serious injury to the eyes or skin due to laser radiation

While using a continuous plane measurement to align the device in Monitor measurement mode, note the following:

- ▶ Align the device preferably with a pilot laser that cannot cause dangerous reflections.
- ▶ Aligning the device with a class 4 laser can result in dangerous reflections.
  In this case, the alignment must be remotely controlled behind a separating protective device.
  The protective device must block the radiation or reduce it to a non-hazardous level.

1. Follow the warning messages in chapter chapter 9.1, „Safety instructions“, on page 27.
2. Click the ***Start*** button.

→ The measurement begins.

Optional:

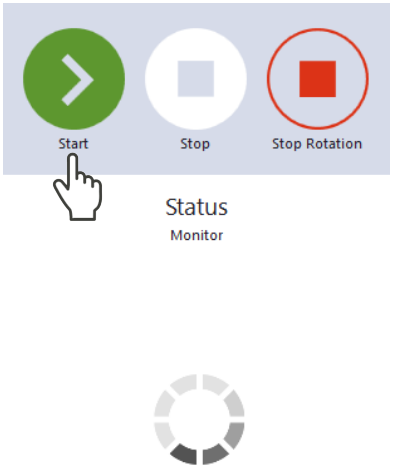
- ▶ Click the ***Stop*** button to abort the measurement.
- ▶ Click the ***Stop Rotation*** button to stop the rotation of the measuring tip.

👁 The measurement progress is shown in the following indicators:

Measuring:
While the indicator is rotating, the measurement is performed.

👁 Measuring planes are continuously viewed in a false-color image.

3. Switch off the laser after the measurement is completed, unless you want to perform further measurements.

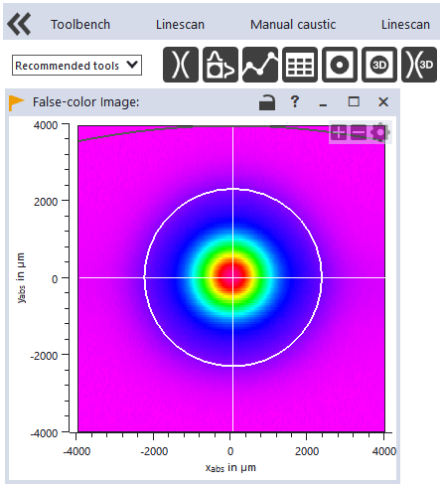


9.9.4 Display measurement results

During the measurement, measurement data is continuously read out and displayed in the graphical view.

The determined measurement data are not saved in the project tree of the Projects tab.

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



9.10 Manual Caustic

In ***Manual Caustic*** measuring mode, only the z-range and the number of plane measurements have to be specified. All other required settings are automatically determined and adjusted. In addition, advanced settings can be applied.

For stigmatic and single astigmatic beams, at least 10 different positions on the z-axis must be measured according to ISO 11146-1. About half of the measurements must be distributed within one Rayleigh length on both sides of the beam waist and about half must be distributed beyond two Rayleigh lengths starting from the beam waist.

For generally astigmatic and unknown beams, ISO 11146-2 requires measurements to be made at a minimum of 20 uniformly distributed points on the z-axis within a range of at least three times the Rayleigh length both behind and in front of the beam waist.

PRIMES recommends measuring at least 21 planes within ± 3 Rayleigh lengths around the focus. An odd number of measurement planes makes it more likely that the focal plane will be measured.

9.10.1 Start measurement

1. Follow the warning messages in chapter chapter 9.1, „Safety instructions“, on page 27.
2. Click the ***Start*** button.

➔ The measurement begins.

Optional:

▶ Click the ***Stop*** button to abort the measurement.

▶ Click the ***Stop Rotation*** button to stop the rotation of the measuring tip.

👁 The measurement progress is shown in the following indicators:

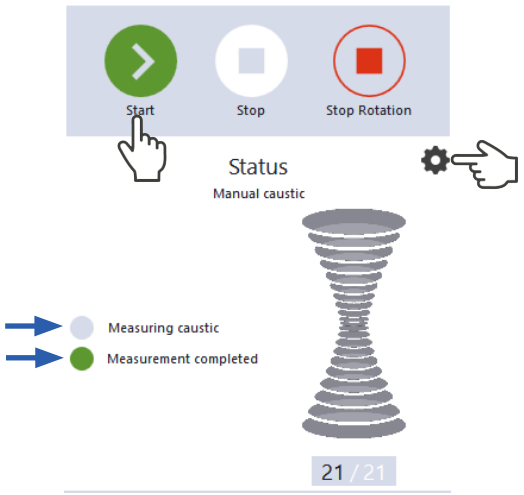
Measuring plane:
While the indicator is rotating, the measurement is performed.

Measurement completed:
After successful measurement, the indicator lights up green.

Averaging (if enabled):
The indication shows the measured planes that are used to average a measured value

Click ***Gear*** will show the ***Magnification***

3. Switch off the laser after the measurement is completed, unless you want to perform further measurements.



9.10.2 Apply a caustic suggestion (optional)

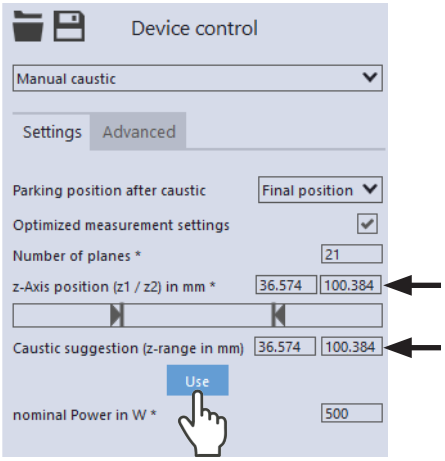
After the measurement is complete a z-area is displayed in the suggested caustic fields, the limits z1/z2 of which are at a distance of ± 3 Rayleigh lengths from the determined beam focus.

This z-area is optimized according to PRIMES quality criteria.

1. If this suggestion is acceptable, click the Apply button.

The suggested values for the z1/z2 limits are transferred to the z-axis position (z1/z2) fields in mm.

2. Start and stop the measurement according to chapter 9.10.1 on page 56.



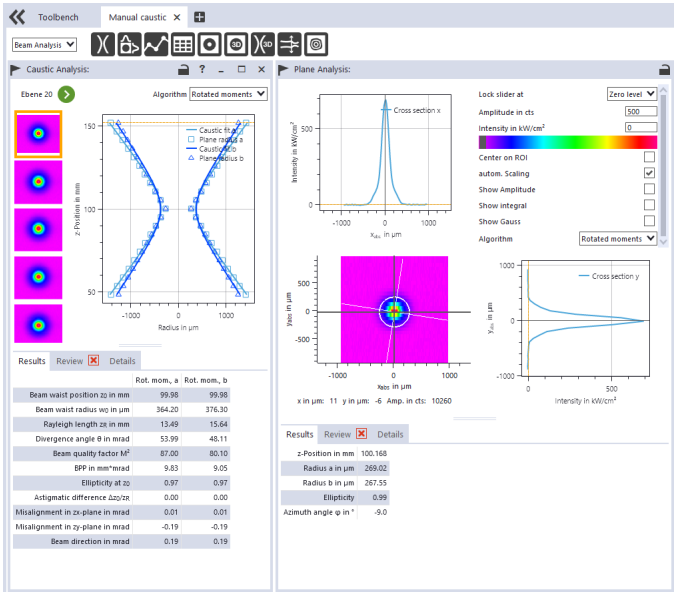
9.10.3 Display measurement results

The measurement results are displayed after the finished measurement in the opened tools.

- PRIMES recommens checking the quality of the results after a measurement.

  Depending on the results, it may seem necessary to repeat the measurement with improved measurement setup or changed parameters.

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



9.11 Automatic Caustic

In ***Automatic Caustic*** measurement mode, just press the start button to automatically determine a caustic. The center position of the z-axis is preset as the start position.

The default setting for the number of measurement planes is 21. The optimal measurement range along the z-axis and all other required settings are made automatically and adjusted if necessary. In addition, advanced settings are also available.

For stigmatic and single astigmatic beams, at least 10 different positions on the z-axis must be measured according to ISO 11146-1. About half of the measurements must be distributed within one Rayleigh length on both sides of the beam waist and about half must be distributed beyond two Rayleigh lengths starting from the beam waist.

For generally astigmatic and unknown beams, ISO 11146-2 requires measurements to be made at a minimum of 20 uniformly distributed points on the z-axis within a range of at least three times the Rayleigh length both behind and in front of the beam waist.

PRIMES recommends measuring at least 21 planes within ± 3 Rayleigh lengths around the focus. An odd number of measurement planes makes it more likely that the focal plane will be measured.

9.11.1 Start measurement

1. Follow the warning messages in chapter chapter 9.1, „Safety instructions“, on page 27.
2. Click the ***Start*** button.

➔ The measurement begins.

Optional:

▶ Click the ***Stop*** button to abort the measurement.

▶ Click the ***Stop Rotation*** button to stop the rotation of the measuring tip.

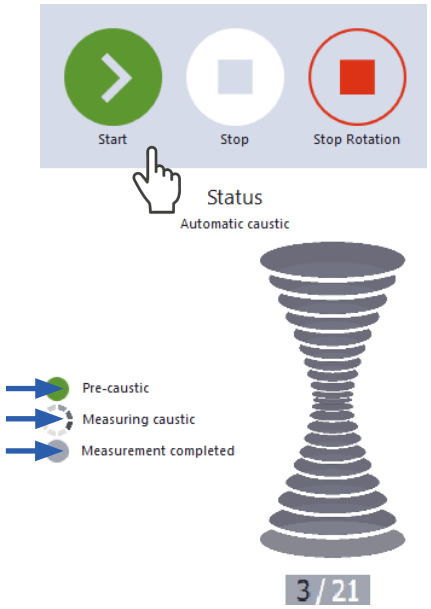
The measurement progress is shown in the following indicators:

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:
While the indicator is rotating, the measurement is performed.

Measurement completed:
After successful measurement, the indicator lights up green.

3. Switch off the laser after the measurement is completed, unless you want to perform further measurements.

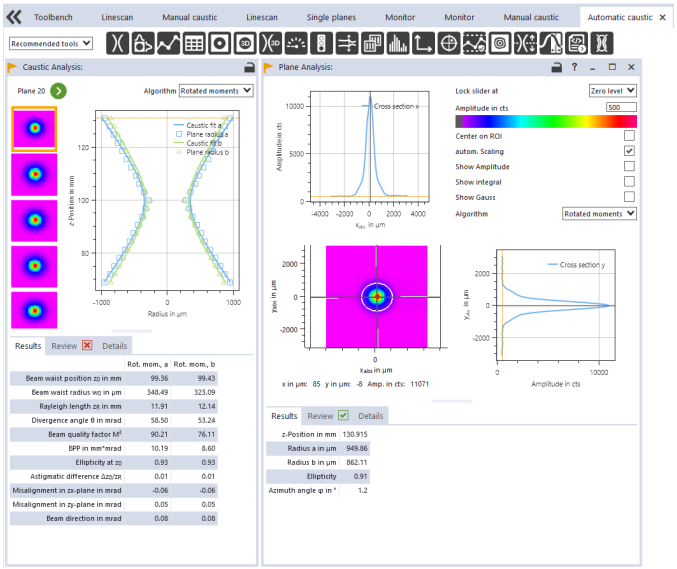


9.11.2 Display measurement results

The measurement results are displayed after the finished measurement in the opened tools.

- ▶ PRIMES recommens checking the quality of the results after a measurement.

  Depending on the results, it may seem necessary to repeat the measurement with improved measurement setup or changed parameters.
- ▶ For a detailed description of the file management and evaluation of the measured data, please refer to the separate operating manual LDS.



9.12 Display of measurement deviation in the LaserDiagnosticsSoftware LDS

Measurements with the FocusMonitor FM+ HPD may show deviations in the power density distribution in the far field of a caustic (> 1 Rayleigh length z_R).

The deviations near the beam waist are very small and the focal plane itself is displayed correctly.

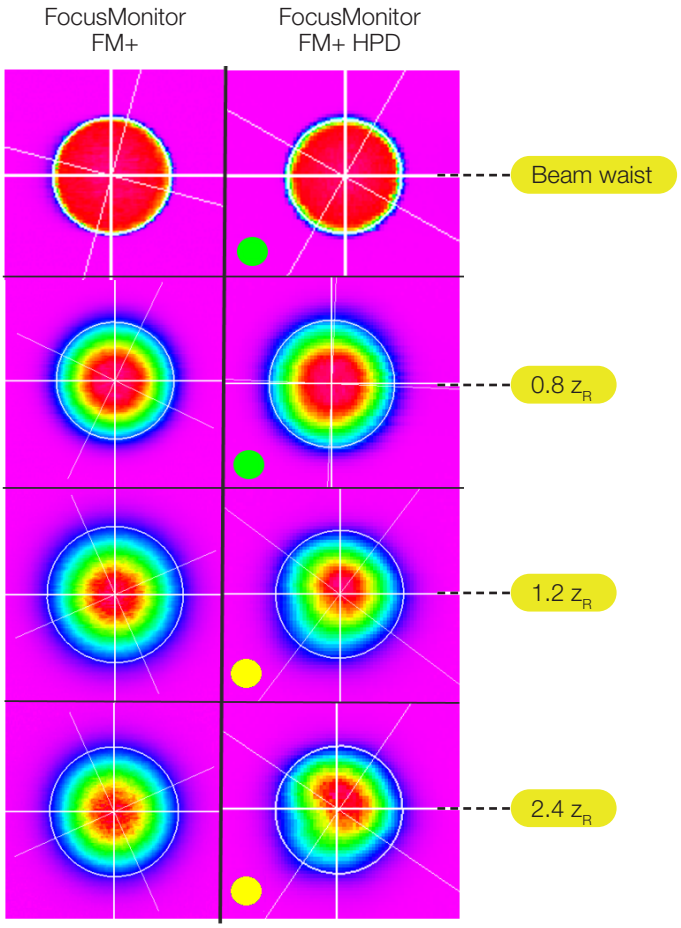
For easier classification, planes are highlighted by a colored dot (green/yellow) in the Laser Diagnostics Software LDS:

- A green dot marks planes close to the focus where the deviation of the power density distribution are very small.
- A yellow dot marks planes located in the far field where the power density distribution may be distorted.
  As these efects differ from measuring tip to measuring tip a plane marked by a yellow dot is not necesseraly effected.

Planes can only be evaluated by the LaserDiagnosticsSoftware LDS if they are available in the project tree as part of a valid caustic measurement.

If no dot is displayed, automatic evaluation by the LaserDiagnosticsSoftware LDS is not possible:

- The caustic is indicated by the LaserDiagnosticsSoftware LDS as not valid.



9.13 Uncertainties in the determination of the beam parameters

Due to possible distortions of the power density distribution in the far field of a caustic, certain beam parameters, may show increased uncertainties. This is taken into account by an increased tolerance range ($\Delta r/r < 10$ %). The specified measurement uncertainties are given in Tab. 9.3 on page 60

Limit values of the beam parameters for safe determination of the beam parameters	
min. beam radius	50 µm
max. beam radius	600 µm
max. power density	50 MW/cm²
Max. beam divergence	120 mrad
Wavelength range	1 000 – 1 100 nm

Measurement uncertainties	
Focus radius r_0	5 %
Beam radius r ($\|z\| < 1\ z_R$)	5 %
Beam radius r ($\|z\| > 1\ z_R$)	10 %
Focus position z_0	3 % z_R
Rayleigh length z_R	15 %
Beam quality factor M²	15 %
Beam divergence	10 %

Tab. 9.3: Limit values and measurement uncertainties

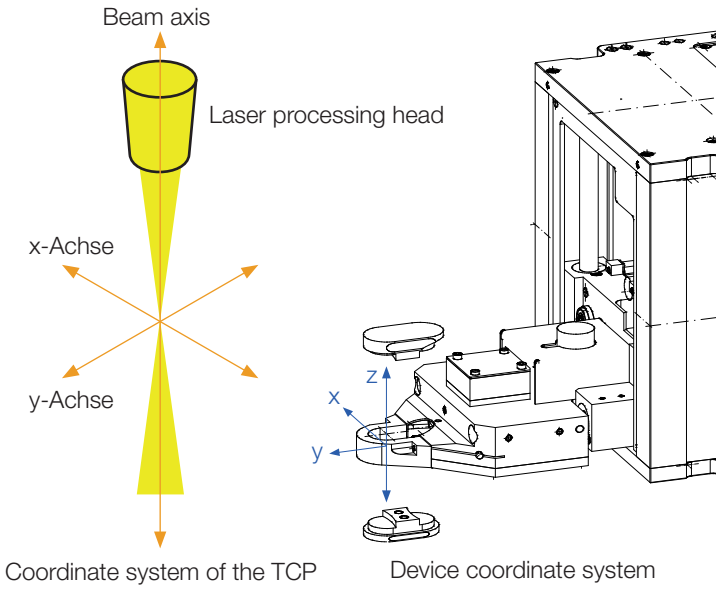
The measurement uncertainties refer to the use of rotationally symmetric algorithms: Invariant moments or 86 %. Other evaluation algorithms may lead to increased uncertainties.

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

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

1. Align the FocusMonitor FM+ HPD as described in chapter 7.2.4 on page 20.
2. Install the FocusMonitor FM+ HPD as described in chapter 7.2.5 on page 22.
3. Perform an automatic caustic measurement as described in chapter 9.11 on page 58.
4. Move the measuring carrier of the FocusMonitor FM+ HPD to the determined focus plane as described in chapter 9.4.3 on page 34.

- The FocusMonitor FM+ HPD moves the reference plane to the focus position (see figures in chapter 9.14.1 on page 62).



5. Measure the Distance z between the reference plane of the horizontal carrier (see figure in chapter 9.14.1 on page 62) and the reference plane on the laser processing head.

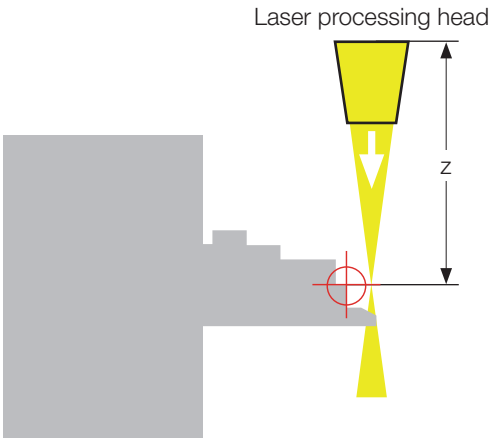
The following description is an example for the further determination of the TCP using a coaxial vision system.

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.



9.14.1 Distance of the diffuser in the FS³ to the horizontal carrier

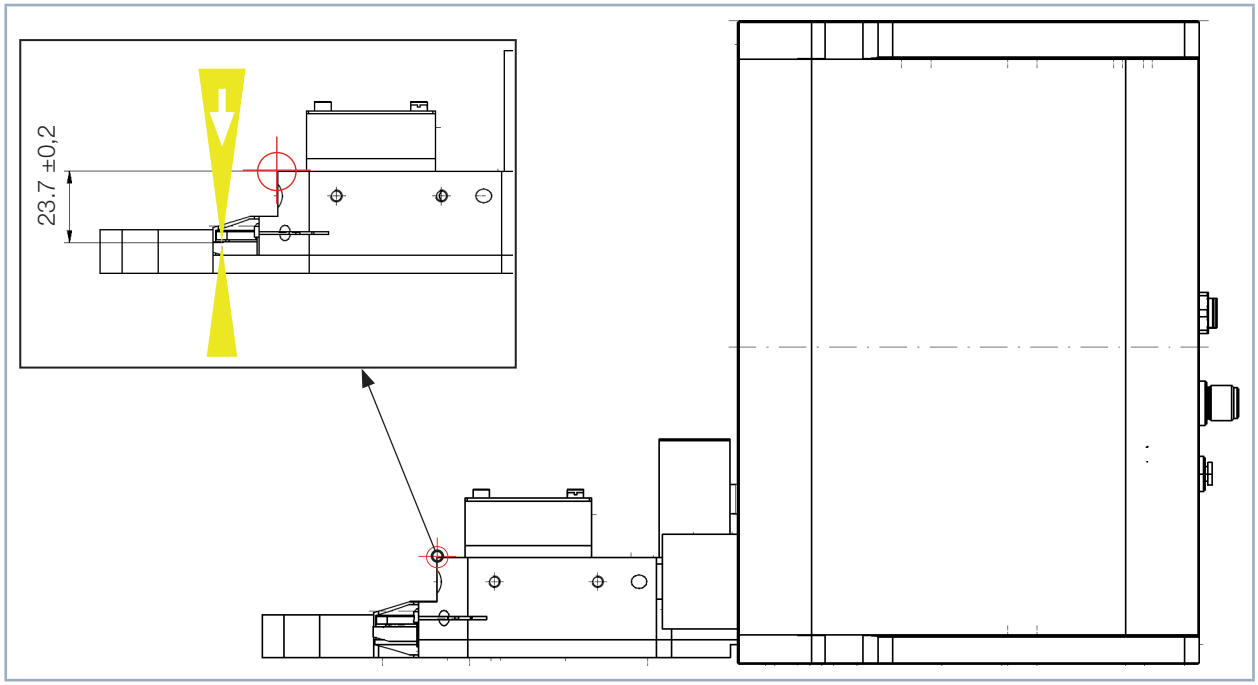


Fig. 9.1: Distance of the diffuser in the FS³ to the horizontal carrier

10 Troubleshooting

10.1 Messages in the LDS during measurement

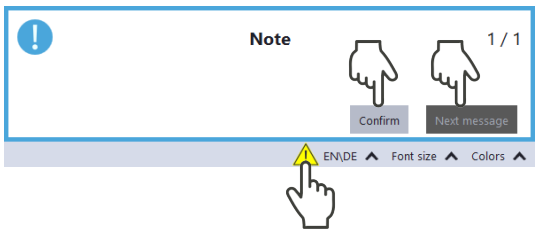
If problems occur during a measurement, the LDS displays them in different categories and different colors.

Note

Notes provide assistance in interpreting the measurement results and are displayed in a blue window.

Use one of the following options:

- ▶ Click on the warning triangle in the footer to display / hide the window.
- ▶ If applicable, click the ***Next message*** button to display more messages of the same category.
- ▶ Click the ***Confirm*** button to remove the displayed message.

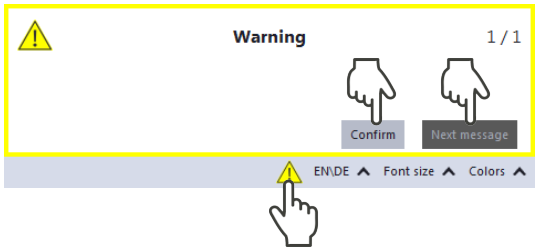


Warning

Non-safety-critical problems that influence the quality of the measurement results, for example, are displayed in a yellow window.

Use one of the following options:

- ▶ Click on the warning triangle in the footer to display / hide the window.
- ▶ If applicable, click the ***Next message*** button to display more messages of the same category.
- ▶ Click the ***Confirm*** button to remove the displayed message.



Device error

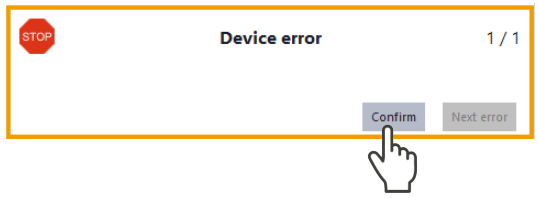
Device errors that can result in damage of the device are displayed in an orange window.

In this case, proceed as follows:

1. Fix the problem.
2. Click the ***Confirm*** button to remove the message.

👁 The message disappears. If the problem is not fixed, then the message appears again shortly afterwards.

3. Do not proceed with the measurement until the problem is solved.



Safety critical note

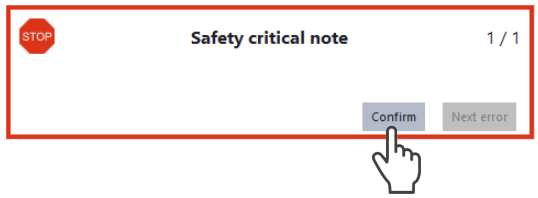
Safety-critical problems that can result in damage/destruction of the device are displayed in a red window.

In this case, proceed as follows:

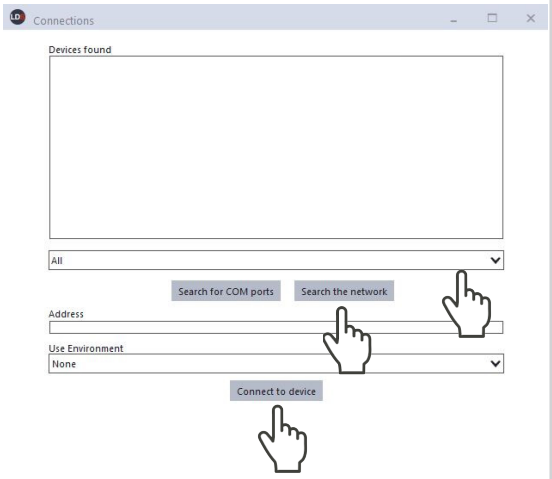
1. Fix the problem immediately.
2. Click the ***Confirm*** button to remove the message.

👁 The message disappears. If the problem is not fixed, then the message appears again shortly afterwards.

3. Do not proceed with the measurement until the problem is solved.



10.2 Connection Error with the LDS

The firewall may block the connection between the device and the LDS: ▶ In ***Windows > Control panel > Firewall***, enable the UDP port 20034.	The UDP port should be enabled by a system administrator.
The IP address of the PC is not within the range of the device. ▶ ***In Windows > Control panel > Network and Sharing Center***, assign an IP address to the PC that is in the same address range as the PRIMES device (e.g. 192.168.116.xyz). The IP address of the PRIMES device can be found on the identification plate.	The IP address should be set by a system administrator.
If several network cards or a USB3-to-Ethernet card are installed in the PC, the connection between device and LDS may be blocked by the selection of the wrong network card. 1. Select the appropriate network card in the ***Connections > All*** window. 👁 The device is displayed in the ***Connections*** window 2. Click on the device. 3. Click on the ***Connect to device*** button.	

10.3 Other Errors

Error	Possible cause	Remedy
Error during 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 signal enhancement is too low.	Set the maximum enhancement and select the maximum measuring range.
The FS³ is being destroyed during the measurement	• The power density is too high • Mechanical damage has occurred	A damaged FS³ must be replaced immediately to ensure safe operation.
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 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.
The display of the measured beam deviates significantly from expectations	Internal defect of the FS³	Contact PRIMES technical support. Email address: support@primes.de. We recommend including some example measurements when contacting us.

Tab. 10.1: Other Errors

11 Maintenance and service

11.1 Maintenance intervals

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.

If the device is used sporadically (less than daily), the maintenance interval can be extended up to 24 months.

11.1.1 Cleaning the device surface

1. After a measurement, let the device cool down for an adequate period of time.
2. Clean the device surface with clean and oil-free compressed air.
3. For further cleaning, use a mixture of distilled water and isopropanol in a ratio of approx. 5:1. Use lint-free cleaning cloths that do not cause scratches.

If these steps are not sufficient, please contact PRIMES or your PRIMES distributor.

Do you need help?

Tutorial videos can be found under the following link:

www.primes.de/en/support/downloads/tutorialvideos/fmplus-hpd.html

NEED HELP?
www.primes.de/de/support/downloads/tutorialvideos/fmplus-hpd.html

11.2 Replace Rotating Disk

⚠ CAUTION

Burns due to hot surface

After a measurement the absorber below the protective window is hot! Unintentional contact during the protective window exchange could lead to burns.

- **Do not exchange the protective window directly after a measurement.**
- **Let the device cool down for an adequate period of time. The cooling time depends on the laser power and the irradiation time.**

Notice

Damage/Destruction of the FS³ measuring tip

Touching the FS³ measuring tip can cause indentations at the points of contact due to the laser radiation. Indentations lead to damage or shattering of the FS³ measuring tip

- Do not touch the FS³ measuring tip.
- When mounting, wear powder-free latex gloves and ensure a clean and dust-free environment.

Notice

Damage/Destruction of the rotation unit

The rotational properties can change if screws other than those installed at the factory or supplied with the rotating disk are used to fasten the rotating disk. This impairs the functionality of the device and leads to damage.

- After removal, carefully store a rotating disk and its associated screws. It must always be identifiable that the disk and screws belong together.
- When fastening a rotating disk, use only the screws installed at the factory or supplied with the disk.

Notice

Damage/Destruction of the device

Imbalance of the rotating disk can lead to damage to the device.

- Never operate the device without a measuring tip.

Do you need help?

Tutorial videos can be found under the following link:

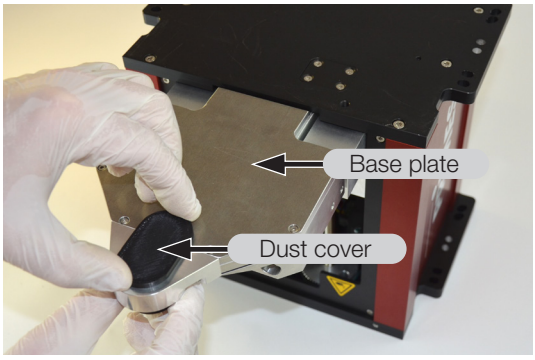
www.primes.de/en/support/downloads/tutorialvideos/fmplus-hpd.html

NEED HELP?
www.primes.de/de/support/downloads/tutorialvideos/fmplus-hpd.html

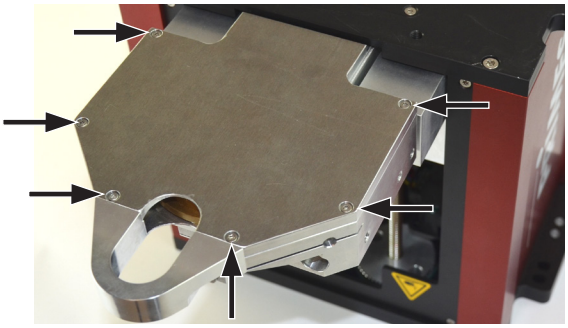
Prepare the following:

- Device with installed FS³ (Device switched off, connections disconnected)
- Torx screwdrivers T8 and T10
- Replacement FS³
- Powder-free latex gloves

1. Put on the latex gloves.
2. Turn the device upside down so that the base plate of the traversing stage is facing up.
3. Remove the dust cover



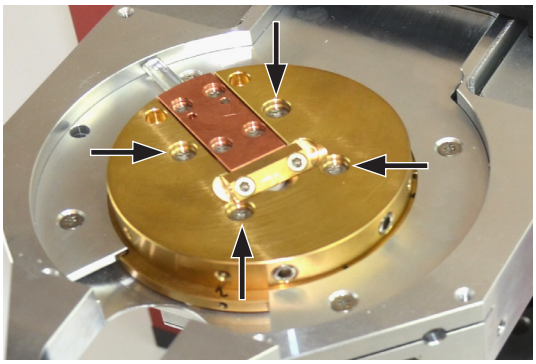
4. Remove the 6 T8 countersunk screw from the base plate.
5. Remove the base plate.



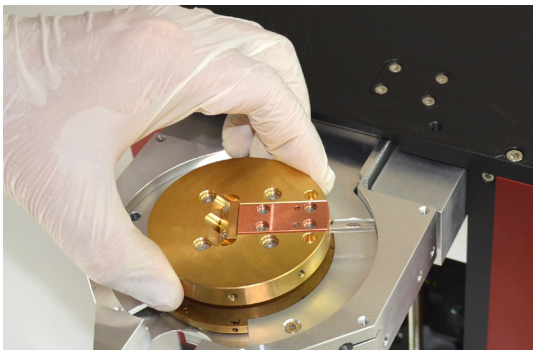
6. Carefully identify the 4 square-arranged T10 countersunk screw of the FS³.

> Never loosen any other screws!

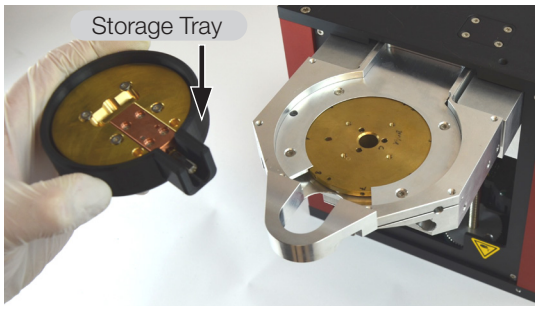
7. Remove the 4 T10 countersunk screw.



8. Carefully lift the FS³ vertically upwards out of the rotation unit.

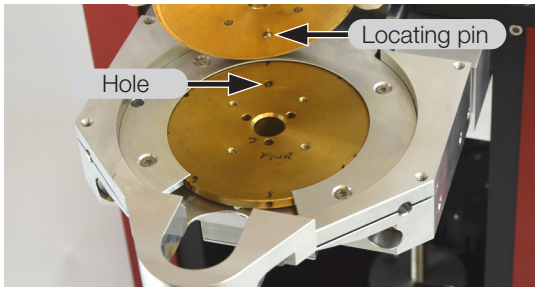


9. Carefully store the rotating disk and its associated screws. Use the PRIMES storage tray if possible



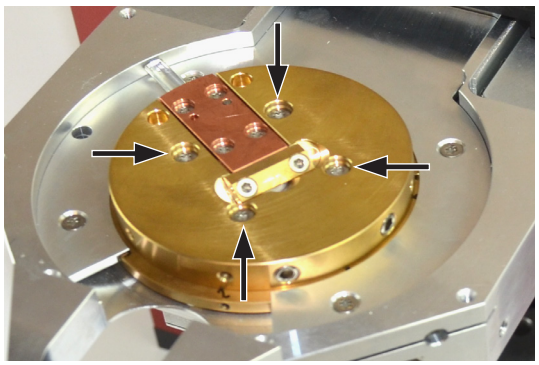
> The FS³ measuring tip must always be protected from contact and contamination.
> It must always be identifiable that the disk and screws belong together.

10. Hold the rotating disk against the rotation unit so that the locating pin is above the hole.
11. Place the rotating disk onto the rotation unit. The locating pin must snap into place to ensure a tight fit of the disk.

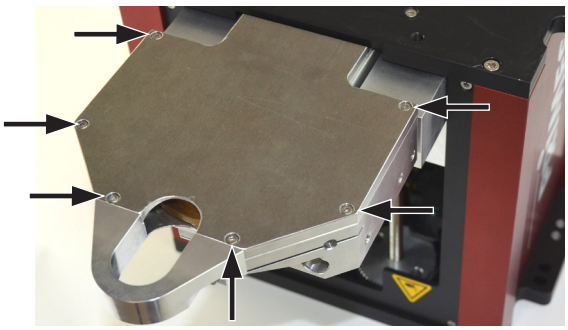


Insert the 4 T10 cylinder head screws and tighten them by hand.

> Only the screws supplied with the disk may be used to fasten the rotating disk!

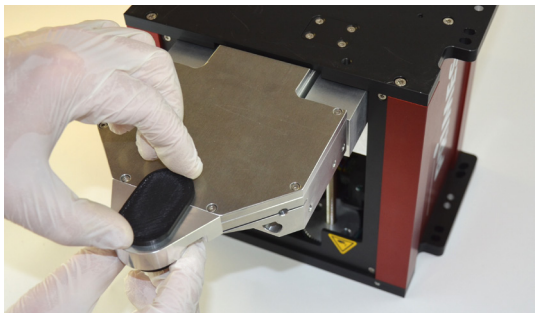


12. Insert the base plate.
13. Insert the 6 T8 countersunk screw and tighten them by hand.



14. Insert the dust cover.

> The top side with the TOP marking must point downwards.



15. Turn the device over.

12 Measures for the product disposal

This PRIMES measuring device is subject to the Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE) and the corresponding national laws.
The WEEE obliges the operating company to dispose of the device in an environmentally sound manner, not with household waste, but in a separate WEEE collection.

PRIMES gives the opportunity to return PRIMES measuring devices for free disposal within the scope of the WEEE. This service does not include shipping costs.
PRIMES measuring devices to be disposed of within the EU can be send to the following address:

PRIMES GmbH

Max-Planck-Str. 2

64319 Pfungstadt

Germany

To process your return as efficiently as possible, please fill out our return form. You can find the form using the QR code opposite or at: www.primes.de/en/create-rma-online.

If you are located outside the EU, please contact your local PRIMES distributor to discuss the disposal procedure for your PRIMES measuring device.

PRIMES is registered with the german „stiftung elektro-altgeräte register“ foundation (stiftung ear) as a manufacturer under the number: WEEE Reg. No. DE65549202.

13 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: FM 35; FM 120; FM+; FM+ HPD; 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 2014/32/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.

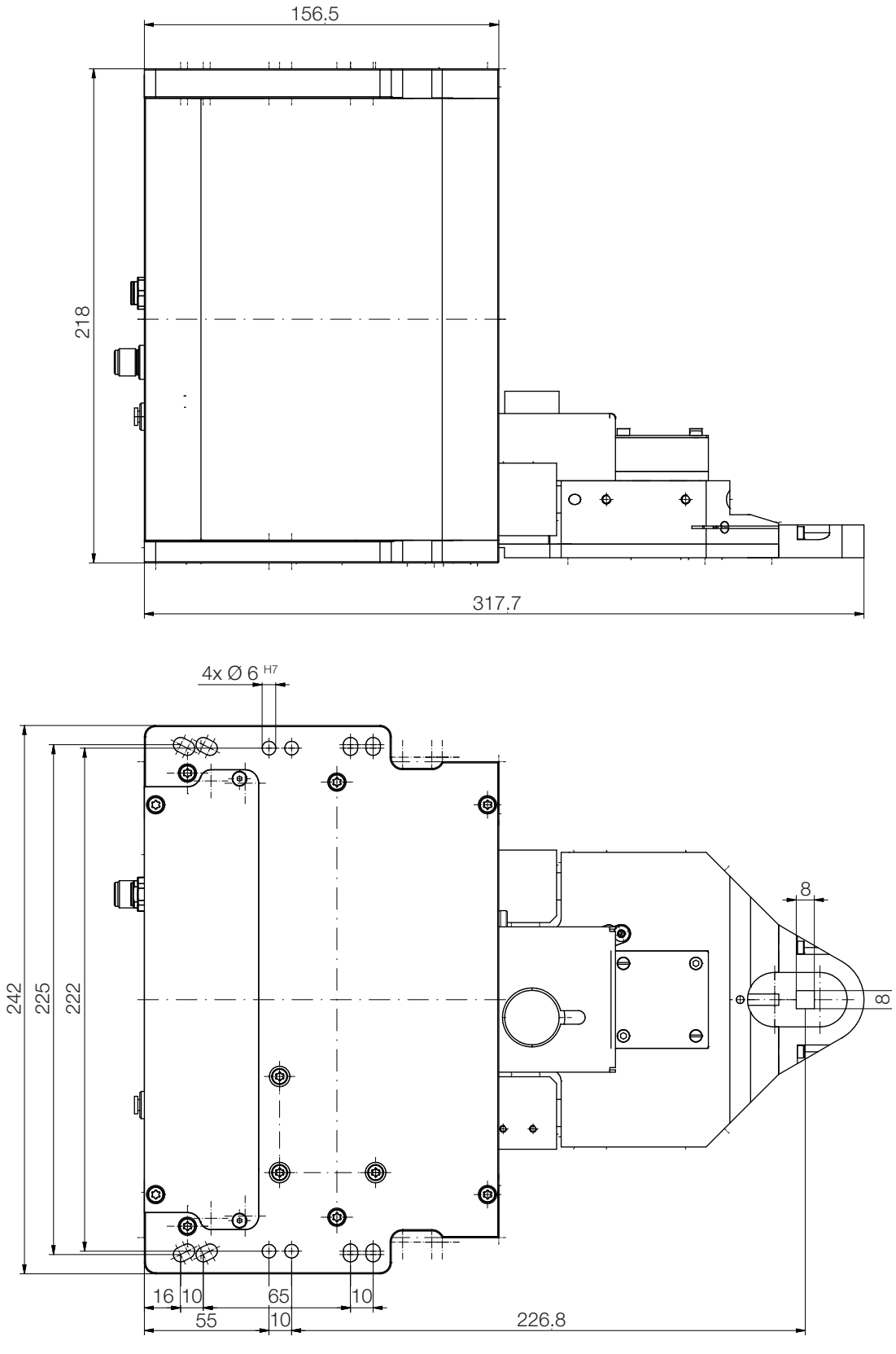
Pfungstadt, November 7, 2019

Dr. Reinhard Kramer, CEO

14 Technical data

Measurement parameters	
Power range	30 – 25 000 W
Wavelength range	515 – 545, 1 000 – 1 100 nm
Beam diameter	100 – 1 200 µm*
Max. power density	50 MW/cm²
Max. beam divergence	120 mrad
* The size of the beam distribution to be measured must not exceed 1 200 µm in the 86 % power inclusion. Within this range, measurement of multispots is also possible.	
Determined parameters	
Focus position x, y, z	yes
Focus radius x, y	yes
Beam quality factor M²	yes
Divergence angle	yes
Power density distribution	2D, 3D
Device parameters	
Working range x-y	8 x 8 mm
Working range z	120 mm
Mechanical aperture	8 x 8 mm
Resolution	32 x 32 – 1 024 x 1 024 pixel
Rotation speed of the FS³	1 875 rpm
Rotation speed of the conventional measuring tip	1 875 rpm or 3 750 rpm
Linescan	yes
Supply data	
Power supply	24 V DC ± 5 %, max. 3.5 A
Inert gas (water and oil free)	Helium, Nitrogen, Argon, compressed air
Specification of compressed air according to ISO 8573-1: 2010	1:4:2
Pressure protective gas	typ. 0.5 bar
Communication	
Interfaces	RS485/Ethernet
Dimensions and weight	
Dimensions (L x W x H)	318 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 %

15 Dimensions



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

16 Appendix

A GNU GPL license notice

The software of this product contains software code that is licensed subject to the GNU General Public License (GPL) Version 2 or later.

The license terms of the GNU GPL Version 2 or later are available on the following websites:

- https://www.gnu.org/licenses/old-licenses/gpl-2.0.en.html
- https://www.gnu.org/licenses/licenses.en.html

B Operating the Device with a conventional measuring tip

Notice

Damage/Destruction of the device or measuring tip

The DFIG-PS+HPD detector is permanently installed in the device and must not be changed. The conventional measurement tips suitable for this detector can withstand lower power densities than the FS³.

▶ Operate the device only with the factory-installed detector.

▶ Use only the appropriate conventional measurement tips and observe their limits.

The device can optionally be operated with a conventional measurement tip with an entrance aperture (pinhole).
The following conventional measurement tips are suitable for use in the FM+ HPD:
NIR high div
Diode
The specifications of the suitable measurement tips are contained in the operating manual of the FocusMonitor FM+. Read chapter 11.5, “Selection of Measurement Tip and Detector” and Appendix B.
You can find the manual in the download area of the PRIMES website at:
https://www.primes.de/de/support/anleitungen.html

When operating with a conventional measurement tip, the device can only be used in standard mounting and not in overhead mounting.
Therefore, observe the correct installation position of the conventional measuring tip.

B.1 Replacing the Rotating Disk and Inserting the Conventional Measurement Tip

CAUTION

Burns due to hot surface

After a measurement the absorber below the protective window is hot! Unintentional contact during the protective window exchange could lead to burns.

- **Do not exchange the protective window directly after a measurement.**
- **Let the device cool down for an adequate period of time. The cooling time depends on the laser power and the irradiation time.**

Notice

Damage/Destruction of the measuring tip

Touching the FS³ measuring tip can cause indentations at the points of contact due to the laser radiation. Indentations lead to damage or shattering of the FS³ measuring tip

- Do not touch the FS³ measuring tip.
- When mounting, wear powder-free latex gloves and ensure a clean and dust-free environment.

Notice

Damage/Destruction of the rotation unit

The rotational properties can change if screws other than those installed at the factory or supplied with the rotating disk are used to fasten the rotating disk. This impairs the functionality of the device and leads to damage.

- After removal, carefully store a rotating disk and its associated screws. It must always be identifiable that the disk and screws belong together.
- When fastening a rotating disk, use only the screws installed at the factory or supplied with the disk.

Notice

Damage/Destruction of the device

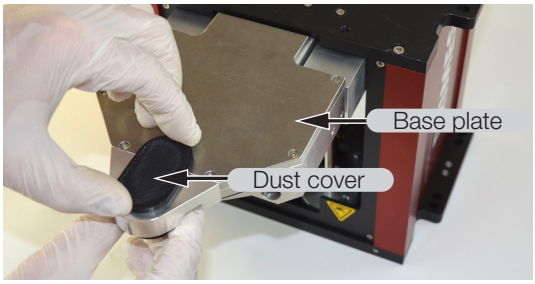
Imbalance of the rotating disk can lead to damage to the device.

- Never operate the device without a measuring tip.

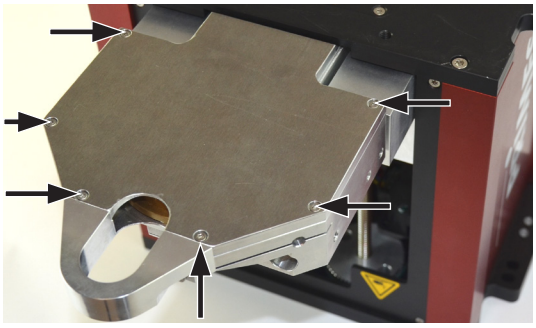
Prepare the following:

- Device with installed FS³ (Device switched off, connections disconnected)
- Torx screwdrivers T8 and T10
- Conventional measuring tip and associated rotating disk
- Powder-free latex gloves

1. Put on the latex gloves.
2. Turn the device upside down so that the base plate of the traversing stage is facing up.
3. Remove the dust cover.



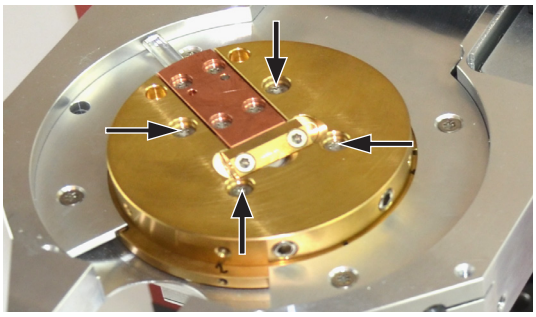
4. Remove the 6 T8 countersunk screw from the base plate.
5. Remove the base plate.



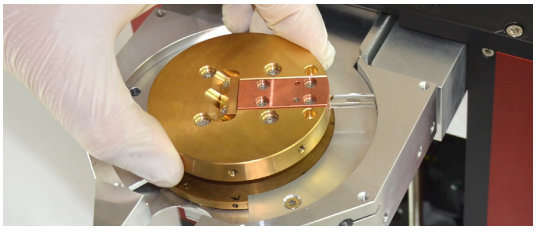
6. Carefully identify the 4 square-arranged T10 countersunk screws of the FS³.

> Never loosen any other screws!

7. Remove the 4 T10 countersunk screws.

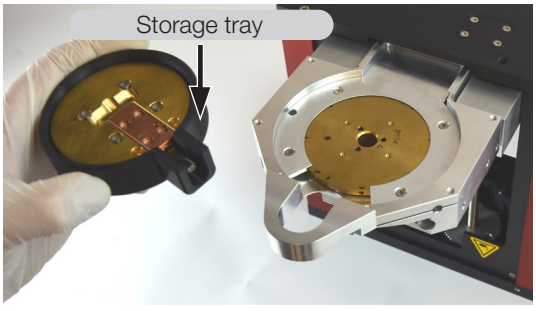


8. Carefully lift the FS³ vertically upwards out of the rotation unit.

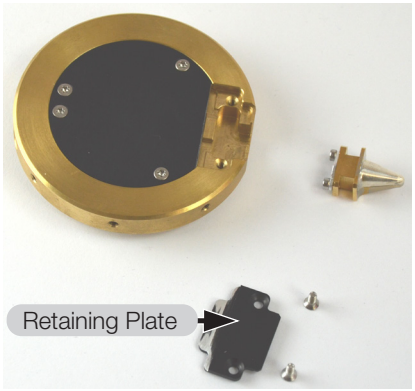


9. Carefully store the rotating disk and its associated screws. Use the PRIMES storage tray if possible.

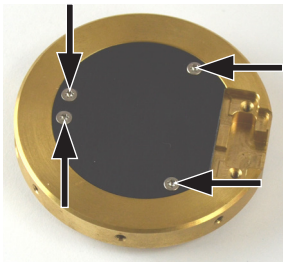
> The FS³ measuring tip must always be protected from contact and contamination.
> It must always be identifiable that the disk and screws belong together.



10. Prepare the conventional measuring tip and its associated rotating disk.
11. Remove the 2 T8 countersunk screws from the retaining plate.
12. Pull the retaining plate upwards slightly, then forwards, until it loosens and can be removed easily.

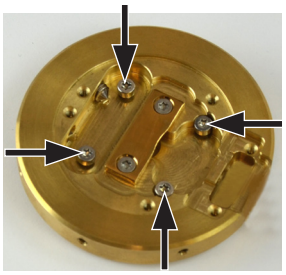


13. Remove the 4 T8 countersunk head screws from the cover of the rotating disk.
14. Remove the cover.

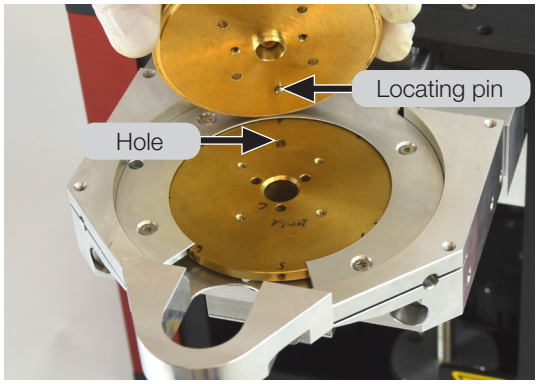


15. Remove the 4 square-arranged T10 cylinder head screws from the rotating disk.

Never loosen any other screws!

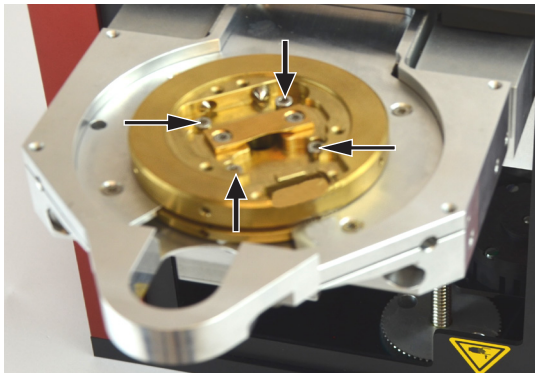


16. Hold the rotating disk against the rotation unit so that the locating pin is above the hole.
17. Place the rotating disk onto the rotation unit. The locating pin must snap into place to ensure a tight fit of the disk.



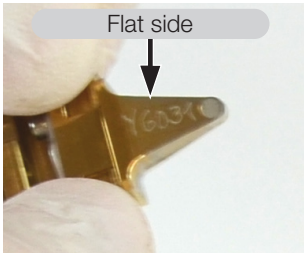
18. Insert the 4 T10 cylinder screws and tighten them by hand.

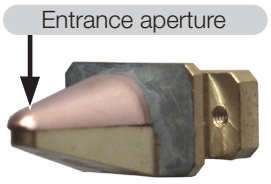
Only the screws supplied with the disk may be used to fasten the rotating disk!



19. Insert the measuring tip so that the flat side is facing up.

> The entrance aperture of the measuring tip is located at the pointed end of the curved side.
> Any contact with the entrance aperture must be avoided!

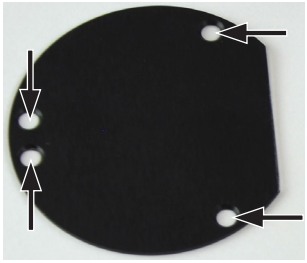




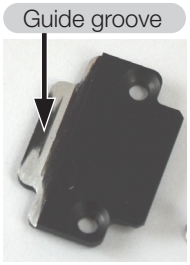
20. Insert the cover into the rotating disk..

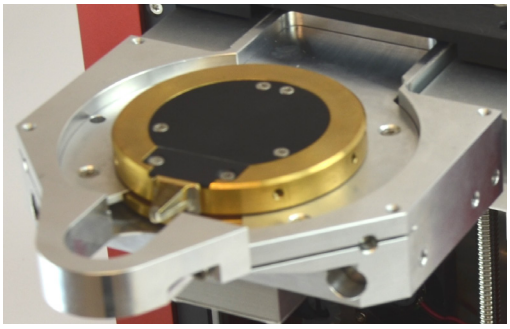
> There are conical bores on the outside.

21. Insert the 4 T8 countersunk screws for the cover and tighten them by hand.

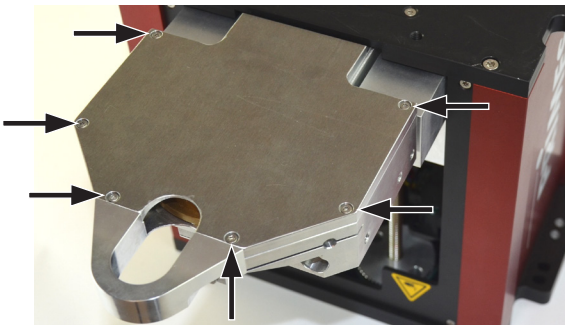


22. Place the guide groove of the retaining plate slightly at an angle under the cover of the rotating disk.
23. Press the retaining plate downwards.
24. Insert the 2 T8 countersunk screws and tighten them by hand.



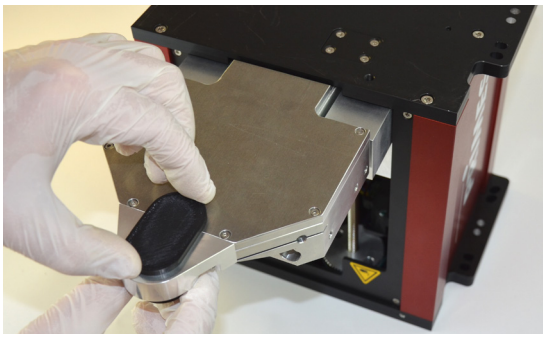


25. Insert the base plate.
26. Insert the 6 T8 countersunk screws and tighten them by hand.



27. Insert the dust cover.

> The top side with the TOP marking must point downwards.



28. Turn the device over.

Measuring with LaserDiagnosticsSoftware LDS

Please note the following additional information to the operating manual when measuring with LDS.

Different z-positions of the determined focus

In a measurement with a conventional measuring tip, the depicted plane is approximately 2.4 mm lower when compared to a measurement with the FS³. The beam focus will then be measured accordingly higher.

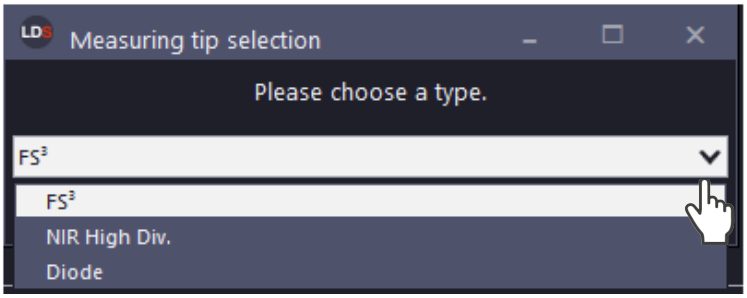
The z-positions determined in different measurements are only directly comparable if the measurements were performed with the same type of measuring tip (conventional or FS³).
In all measurement modes, there is an option „Focus selected caustic“ in the Advanced tab. This can only be used if the selected caustic measurement was performed with the FS³.

Measuring Tip Selection

After clicking the Connect Device button, the measuring tip selection dialog appears.

Select the mounted measuring tip.

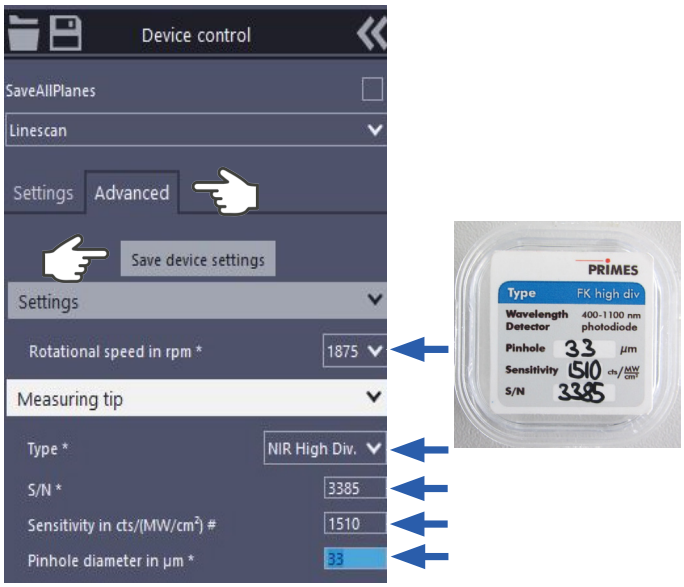
Set the parameters of the measuring tip according to chapter , „Inputs for the Used Measuring Tip“, on page 79.



Inputs for the Used Measuring Tip

To ensure traceability of measurements performed with a specific measuring tip, the specifications of the used measuring tip can be entered into LDS. The specifications are indicated on the packaging of the measuring tip. Missing entries have no effect on the measurements performed.

1. After opening the Device Control menu, click Advanced.
2. Select the type of the used measuring tip from the drop-down list.
3. Enter the serial number S/N of the used Measuring tip.
4. Enter the sensitivity in cts/(MW/cm²) of the used measuring tip.
5. Enter the pinhole diameter in µm of the used measuring tip.
6. Select the rotation speed of the measuring tip from the drop-down list.
7. Click the Save Device Settings button.



B.2 Distance of the entrance aperture (pinhole) to the reference plane

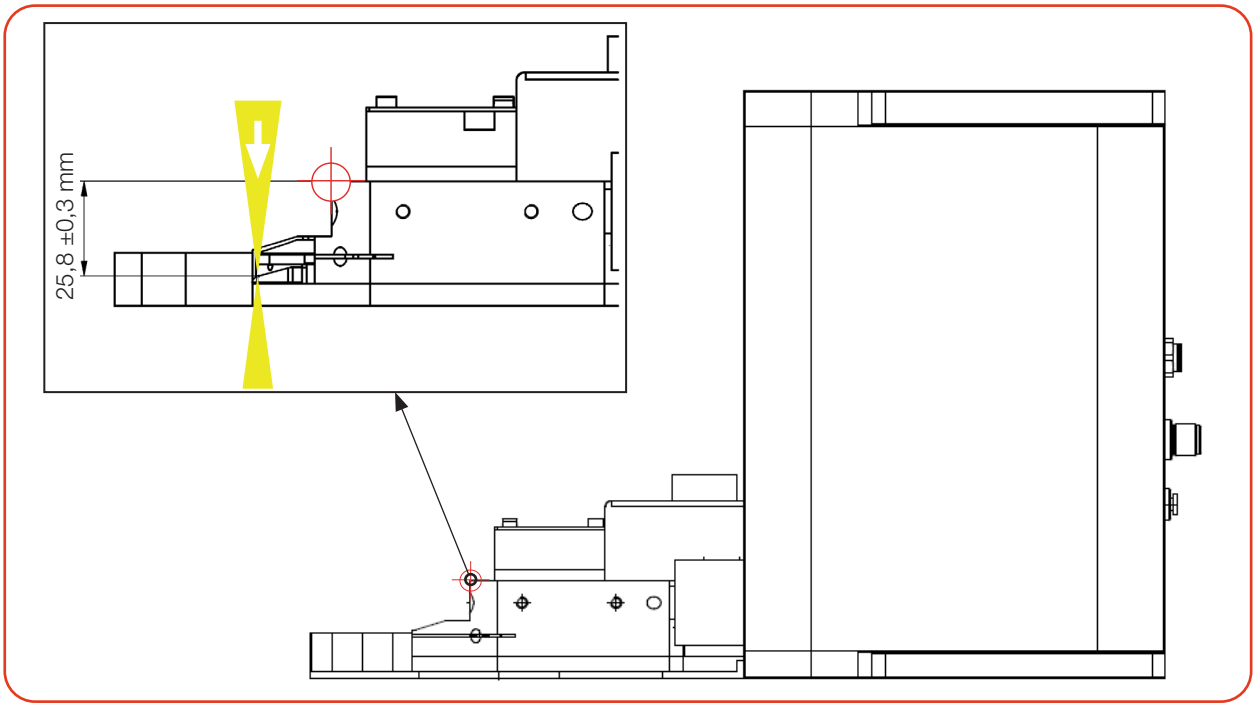


Fig. B.1: Distance of the entrance aperture (pinhole) to the reference plane on the horizontal carrier.