MultiRAM

User Manual

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This manual is the original documentation for the MultiRAM spectrometer.

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1 Introduction

1.1 About this manual

This manual is a complete documentation about the MultiRAM spectrometer.

Depending on the degree of hazard important safety information and safety instructions are classified as follows:

DANGER

➢ Indicates a hazardous situation which, if not avoided, will result in death or serious (possibly irreversible) injury.

WARNING

➢ Indicates a hazardous situation which, if not avoided, could result in death or serious (possibly irreversible) injury.

CAUTION

➢ Indicates a hazardous situation which, if not avoided, may result in minor or moderate (reversible) injury.

NOTE

➢ Hazard, which could result in material damage if the appropriate safety instructions are not observed.

i The *i* provides information given to the user to facilitate spectrometer operation, and make the best possible use of the spectrometer.

1.2 Terms

This manual uses both the term *spectrometer* or MultiRAM when the spectrometer is described.

1.3 Safety

Always observe the instructions described in this manual to ensure user safety and to avoid property damage. Keep this manual for further reference available at any time.

Improper use or failure to follow the safety instructions can result in serious injuries and/or property damage. Any non-observance infringes the intended use (i.e. spectroscopic measurements) of the spectrometer. In this case Bruker Optik GmbH does not assume any liability.

It is the operator's duty to plan and implement all necessary safety measures and to supervise their observance. Moreover, the operator must ensure that the spectrometer is in proper condition and fully functioning. A safe and faultless operation can only be guaranteed if the spectrometer is transported, stored, installed, operated and maintained properly according to the procedures and instructions described in this manual.

Never remove or deactivate any supporting safety systems during spectrometer operation. Objects and/or material not required for operation must not be kept near the spectrometer operating area.

The spectrometer has been developed according to the EN 61010-1:2010 (IEC 61010-1:2010+Cor.:2011) safety regulations for electrical measuring, control and laboratory devices.

1.3.1 Warning labels

When operating the spectrometer you have to observe a number of safety instructions which are highlighted by the appropriate warning label. The warning labels and their meaning are described in the following.

All warning labels on the spectrometer must always be kept legible. Immediately replace worn or damaged labels.

Label	Definition
	**General Hazard:** This warning symbol indicates general hazard. Observe the safety instructions and follow the precautions described to avoid personal injury.

Table 1.1: Warning labels

Label	Definition
	**Frostbite:** This warning symbol indicates cryogenic liquids (e.g. liquid nitrogen) required to operate the spectrometer (e.g. cooling detector). Exposure to these liquids or cooled components causes frostbite effects. Handle the liquids with utmost care. Observe the safety instructions for operating with cryogenic liquids.
	**Hot Surface:** This warning symbol refers to components and surfaces which can become very hot during spectrometer operation. Do not touch these components and surfaces. Risk of skin burn! Be careful when operating near hot components and/or surfaces.
	**Laser Radiation:** This warning symbol indicates the existence of laser radiation. Never look directly into the laser beam, or use any kind of optical instruments to look into the beam as this may cause permanent eye damage.

Table 1.1: Warning labels

1.3.1.1 In case of hazardous sample material

Besides the dangers described above, there can also be hazards caused by the sample material. Depending on the type of hazardous substances used, you have to observe the specific substance-relevant safety instructions. Put on the specific warning label on the corresponding module position. The label must be legible and permanently discernible.

The following list exemplifies types of hazardous sample material:

Label	Definition
	**Infectious Material** This warning symbol indicates the possible existence of biologically dangerous and infectious material. When working with this kind of material always observe the prevailing laboratory safety regulations and take necessary precautions and disinfection measures (e.g. wearing protective clothing, masks, gloves etc.). Non-observance may cause severe personal injury or even death. For information on how to use, dilute and efficiently apply disinfectants, refer to the Laboratory Biosafety Manual: 2004 by WHO - World Health Organization.

Table 1.2: Warning labels in case of hazardous sample material

Label	Definition
	**Radioactive Material** This warning symbol indicates the possible existence of radioactivity. When working with radioactive material always observe the safety regulations and take necessary protective measures. Wear protective clothing, e.g. masks and gloves. Non-observance may cause severe personal injury or even death.
	**Corrosive Substances** This warning symbol indicates the possible existence of corrosive substances. When working with corrosive substances always observe the laboratory safety regulations, and take protective measures (e.g. wear protective masks and gloves). Non-observance may cause severe personal injury or even death.

Table 1.2: Warning labels in case of hazardous sample material

1.3.2 Waste disposal

Dispose all waste produced (chemicals, infectious and radioactively contaminated substances etc.) according to the prevailing laboratory regulations. Detergents and cleaning agents must be disposed according to the special waste regulations.

1.3.3 Laser safety

Depending on its configuration the spectrometer is classified either in laser class 1, 3B or 4 according to EN 60825-1:10-2007 - *Safety of laser products (Part 1): Guidelines for the safe use of laser beams on humans* (IEC/TR 60825-8:2006).

i

Important: The respective laser class is identified by laser warning labels which are located on the spectrometer. Below the laser warning label, an information label is attached which informs about the wavenumber and power value of the laser radiation accessible to the user (not in case of laser class 1).

Observe the safety instructions for laser safety in this user manual as well as the country-specific regulations applied when operating laser systems. The laser system must never be manipulated!

1.3.3.1 Laser class 1

In case of Raman systems belonging to laser class 1, the laser radiation is not accessible to the user. Special precautions are not necessary with laser systems of laser class 1, according to EN 60825-1:10-2007.

The following laser warning label is attached to Raman systems belonging to laser class 1:

Figure 1.1: Laser warning label for laser class 1

1.3.3.2 Laser class 3B and 4

In case of Raman systems belonging to laser class 3B and 4 the laser radiation is accessible to the user. According to EN 60825-1:10-2007, there are special precautions which need to be observed!

Depending on the power of the integrated laser, the classification of the Raman system changes as follows:

- laser safety class 3B: with a power ≤500 mW
- laser safety class 4: with a power >500 mW

WARNING

Risk of emitting laser radiation

Serious (possibly irreversible) eye and skin injury

➢ The operator must observe the necessary precautions!

➢ In case of non-operation, keep the laser system inaccessible to unauthorized persons!

➢ Do not look directly into the laser beam nor use any kind of optical instruments to look into the laser beam. Besides, avoid any skin contact. Non-observance of these safety instructions can cause severe personal injury (e.g. permanent eye damage)!

➢ Protect your eyes against the laser radiation of the Raman system by wearing laser protective glasses (full and alignment protection) according to EN 207 and EN 208. Wear appropriate laser protective clothes (e.g. gloves).

➢ Protect the area around the sample stage via corresponding barriers, warning signs etc.

➢ Pay attention to the corresponding laser safety label. Make sure that the laser safety labels are always well legible. Replace worn labels, if necessary!

A Raman system is a product of laser class 3B or 4 according to EN 60825-1:10-2007, only if:

- accessories are connected to the Raman system, which make laser radiation accessible.

The following laser warning labels are attached to Raman systems belonging to laser class 3B and 4:

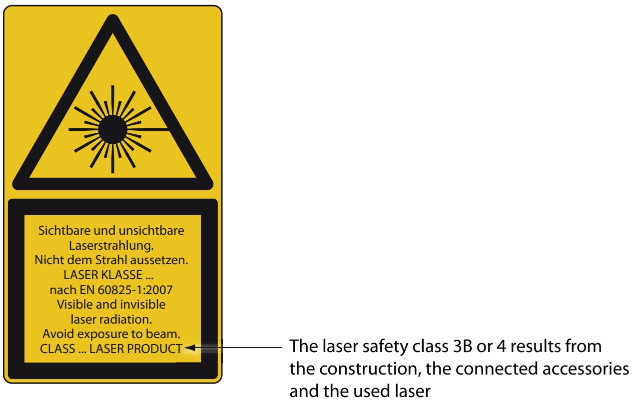

Figure 1.2: Laser warning label for laser class 3B and 4

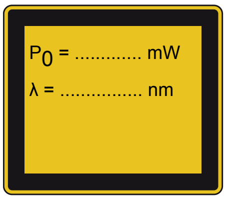

Figure 1.3: Information label

1.3.4 Nominal ocular hazard distance (NOHD)

In case of laser class 3B or 4, the Nominal Ocular Hazard Distance (NOHD) must be observed. This applies both for ideally diffused as well as for direct radiation.

For diverging laser types, the NOHD value implies the danger zone in which there is the risk of health damage on the eye and on the skin when directly or indirectly looking into the laser beam.

Table 1.3 contains the NOHD limits for MultiRAM. The NOHD limits are determined according to the safety directive for artificial optical radiation 2006/25/EG and EN 60825:1-2007. The NOHD limits should support the selection of appropriate protective equipment to be provided for the user, and implement national regulations on working conditions.

	Laser type [nm]	Nominal laser power [mW]	Focal length on aperture [mm]	NOHD value [cm]
Ideally diffused radiation	1064	1000	33	5
			43	5
	785	500	33	7
			43	7
Direct radiation	1064	1000	33	230
			43	300
	785	500	33	290
			43	375

Table 1.3: NOHD values for MultiRAM depending on laser type used

1.4 General information

1.4.1 Protective earthing

To avoid personal injuries and/or damage caused by electrical power, the supplied spectrometer power cord is equipped with a safety plug. Connect this safety plug only to an earthed power socket. Make sure that the earthed power socket used complies with IEC (International Electrotechnical Commission[1]).

1.4.2 Qualified personnel

Initial installation and all maintenance and repair work not described in this manual should only be performed by Bruker service personnel. Make sure that the spectrometer is only operated and maintained (i.e. only maintenance work that is described in this manual) by authorized operating personnel trained in the spectrometer operation and all relevant safety aspects.

All repairs, adjustments and alignments on any spectrometer component must be performed in accordance with the safety regulations and standards applied in the country where the instrument will be installed.

1.4.3 Intended use

The spectrometer and its components should only be used according to the instructions described in the manual or advised by a Bruker engineer.

In case of accessories or components made by other manufacturers and used in connection with the spectrometer, Bruker Optik GmbH does not assume any liability for safe operation and proper functioning.

1.5 Questions and concerns

If you have questions or concerns about safety, operating the spectrometer, or if you need assistance with software problems or replacement parts, contact Bruker at the numbers listed below:

- Service hotline hardware: +49 (0) 72 43 504-2020
- Service hotline software: +49 (0) 7243 504-2030
- Fax: +49 (0) 72 43 504-2100
- E-mail: service@brukeroptics.com
- Internet: www.bruker.com

1. International standards organization for electrical and electronic-related technologies.

2 General

MultiRAM is a stand-alone FT-Raman spectrometer and has been developed for routine applications as well as for demanding laboratory analysis. The spectrometer provides a spectral range of 3600 to 50 cm^{-1} (Stokes shift) and is suited for Raman measurements with a laser excitation of 785 or 1064 nm.

2.1 Spectrometer configuration

2.1.1 Standard configuration

MultiRAM
Standard configuration for Raman measurements of solids and liquids

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ℹ In the standard configuration, the MultiRAM spectrometer is specified as laser class 1 product according to EN 60825-1:10-2007 (safety of laser products).

2.1.2 Optional configurations

- RamanScope III connected to MultiRAM
- MultiRAM with process FT-Raman probes R361 or R362
- MultiRAM with video probe R265

i In optional configurations with probes, the MultiRAM spectrometer is specified as laser class 3B or 4 product according to EN 60825-1:10-2007 (safety of laser products).

Details on the optional configurations are described in chapter 11.

2.2 Design

To configure the spectrometer the following components are required:

- Filter set (including Rayleigh and primary filters)
- Excitation laser to generate Raman scattering: 1064 nm (standard), 785 nm (option)
- Raman detector including adaptation

Optical components, e.g. source, sampling stages, filters, polarizers, detector etc. are electronically coded so that the spectrometer firmware can recognize them.

A large front-mounted sample compartment is equipped with a motorized sample stage and a white light source. Optionally, 90° scattering geometries are available with standard sampling optics.

Pre-adjusted, interchangeable lenses and sample stages allow a comprehensive adaptation to most spectroscopic problems. In case of highly absorbing materials the laser beam can be expanded to reduce the power density of the exciting laser radiation. Alternatively, there is the option to couple laser into an external fiber optic port (chapter 11).

Full support of industry standard communication protocols makes the integration simple. In addition, the permanent online check of spectrometer components facilitates error diagnostics and maintenance.

i Depending on the spectrometer configuration ordered, the spectrometer may not include all options that are described in this manual.

2.3 Applications

The spectrometer can be used to analyze solid and liquid samples (in vials).

2.4 Spectrometer housing

Under no circumstances is the operator allowed to open the sealed spectrometer housing.

2.5 Optics

The optics compartment cannot be accessed by the user. In the standard configuration MultiRAM is either equipped with a room temperature InGaAs detector, or a proprietary high-sensitivity LN_2-cooled Ge detector, which has a sensitivity of up to 5 times higher than a room-temperature detector and is preferably used to analyze complex samples. Optionally, you can use a thermoelectrically stabilized Si avalanche detector.[1]

Highly stable Raman light sources and high-throughput collecting optics provide optimum sensitivity. A complete set of sample holders and test samples is included in each FT-Raman system.

The spectrometer uses a permanently aligned ROCKSOLID interferometer which ensures a high energy throughput and low polarization effects.

The beam inlet and outlet port at the right spectrometer side (see chapter 11) optionally allow to connect external accessories such as:

- RamanScope III
- FT-Raman probes

Each port recombines the beam directed to and returned from the sample by means of IR modules. Diagnostic routines help to maintain optimum instrument status and performance.

2.6 Electronics

The spectrometer electronics are based on a high speed 24 bit data sampling unit that guarantees experimental results with an outstanding accuracy. Any modern data system (PC workstation, laptop etc.) with the OPUS spectroscopy software installed can be used to control the instrument and perform data processing. The spectrometer is linked to the data system by a standard 100Base-T Ethernet connection, which allows the spectrometer to be integrated into an existing data network.

The spectrometer is completely software controlled. All components can be operated using the OPUS spectroscopy software. Diagnostic routines help to maintain optimum status and maximum instrument performance.

1. Ge or InGaAs detector types require a laser with a wavelength of 1064 nm. Si avalanche detector types require a laser with a wavelength of 785 nm.

3 Installation

Unpacking and initial installation of the spectrometer is done by Bruker service. The operating company has to provide an installation site that meets the site requirements described in this chapter.

3.1 Scope of delivery

The standard spectrometer configuration allows upgrading with additional components and/or accessories.

Standard components:	• MultiRAM spectrometer • Power cord • Data cable (CAT 5, crossover cable for 10Base-T Ethernet standard) • CAN bus cable • MultiRAM user manual • Spare parts • Sampling kit
Optional components:	• PC-compatible data system (including power cord and VGA cable) • OPUS application software packages (e.g. QUANT, IDENT, VIDEO, MAP) and the respective user manuals • Accessories • Raman Sadtler libraries

Table 3.1: Scope of delivery

3.2 Packaging

NOTE
Damaged packaging Property damage ➢ Contact shipping company. ➢ Do NOT put spectrometer into operation.

3.3 Transportation

Due to its weight (approx. 72 kg) the spectrometer has to be carried by at least 2 persons. When transporting the spectrometer, use the original packaging to avoid damages.

3.4 Site requirements

The operating company has to provide an installation site that meets the following site requirements:

Environment:	• Temperature range: 5 - 35°C • Humidity (non-condensing): less than 80% (relative humidity) • Temperature variations: less than 1°C/hour and not more than 2°C/day in case of long-term measurements • Do not install devices such as large electric motors, heaters, welding equipment, radio transmitting equipment, units emitting pulsed NMRs, or high-powered lasers in close vicinity to the spectrometer. These devices can cause a spectrometer malfunction. • Make sure that these types of devices are not connected to the same electrical circuit as the spectrometer.

Table 3.2: Site requirements

Inductive electrical interference:	Do not install the spectrometer near any sources of potential inductive electrical interference (e.g. pumps, switching motors, microwave ovens etc.), sources of high energy pulses, and sources that might cause magnetic or radio frequency interference.
Line-powered accessories:	• Line-powered accessories connected to the spectrometer interfaces such as Ethernet have to provide special electrical disconnecting features. • The electric circuits of these interfaces have to comply with SELV circuit (Safety Extra Low Voltage circuit) requirements, even if the connection has already been realized. i Typically, this is achieved when connecting SELV circuits to each other. In general, the interface requirements are met if the accessories comply with the regulations outlined in EN 61010 (Safety regulations for laboratory equipment) or EN 60950 (safety for information technology facilities).
Main power supply:	Ensure easy accessibility at any time
How to interrupt mains power supply?	Either by unplugging the power cable from the mains outlet, or from the external power supply unit.
Power supply:	• Voltage range: 100 - 240 V AC • Frequency range: 50 - 60 Hz • Protection class: I • The power supply unit adapts to the most power sources commonly used. • Use an UPS (Uninterruptible Power Supply) unit to ensure an uninterruptible power supply, and subsequent uninterruptible operation, if there are any problems concerning main power supply caused by e.g. drop-outs and flickers, power surges, frequent thunderstorms etc.
Space:	• Stable and horizontal base • Spectrometer dimensions: 97 x 85 x 29 cm (w x d x h) • At least 25 cm (10“) clearance has to be available at all spectrometer sides, and that the distance between data system and spectrometer does not exceed 100 m.
Vibrations:	• Do not locate the spectrometer near vibration sources (ventilation hoods, air conditioners etc.). • Do not locate the spectrometer in rooms with intense floor vibrations.

Table 3.2: Site requirements

3.5 Connection ports

3.5.1 Electronic ports and ON/OFF switch

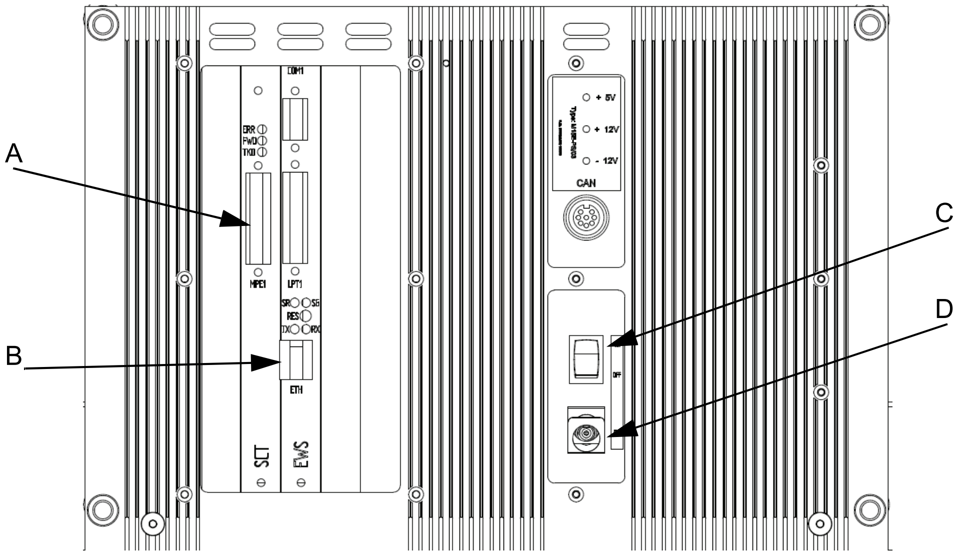


Figure 3.1: Spectrometer rear side with electronic ports and ON/OFF switch

	Definition
A	MPE 1 female connector
B	Ethernet (ETH) female connector
C	ON/OFF switch
D	Power port

Table 3.3: Legend for electronic ports and ON/OFF switch

The ports are described in more detail in chapter 10.

3.5.2 CAN Bus and purge gas ports

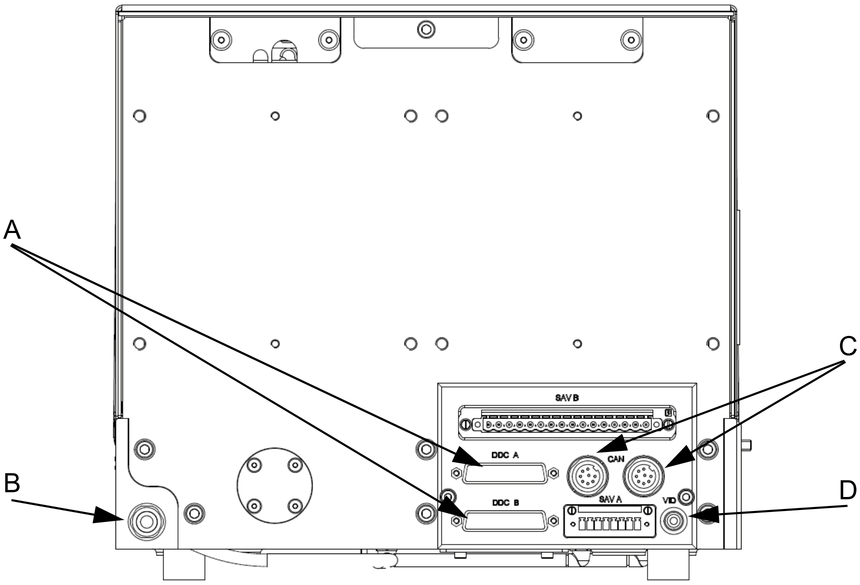


Figure 3.2: Spectrometer rear side with CAN Bus and purge gas ports

	Definition
A	Connector for external detectors
B	Purge gas inlet port for Raman sample compartment
C	CAN bus ports
D	Connector for video accessories

Table 3.4: Legend for CAN bus and purge gas ports

The ports are described in more detail in chapter 10. More types of purge gas ports are described in chapter 3.9.1.

3.5.3 External power supply unit

The standard spectrometer configuration is equipped with the following external power supply unit.

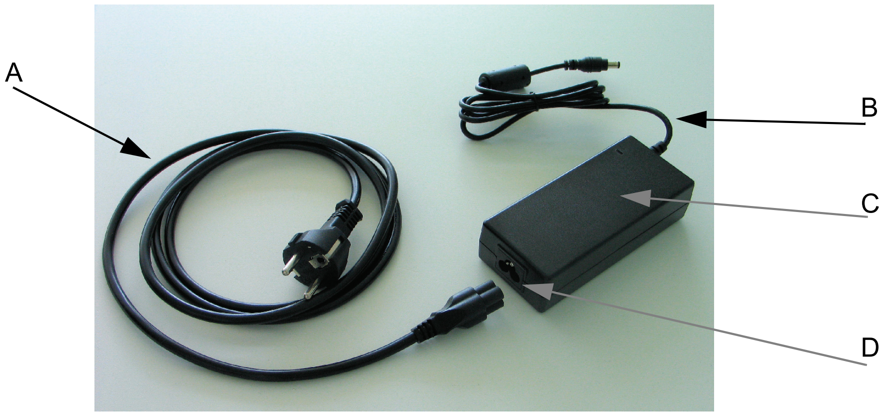


Figure 3.3: External power supply unit with power cord

	Definition
A	Power cord
B	Low-voltage connector
C	External power supply unit
D	C5 socket

Table 3.5: Definition of external power supply unit components

3.6 Installing hardware

For initial installation, all necessary hardware components are connected and installed by Bruker service.

When relocating the spectrometer, observe the installation steps for the standard configuration described in the chapter 3.6.1 et seq. In case of questions on hardware installation contact Bruker service. For contact details see chapter 1.5.

To install the spectrometer in case of optional configuration types see chapter 11.

3.6.1 Connecting spectrometer to power supply

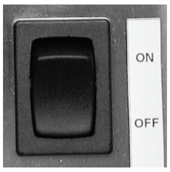
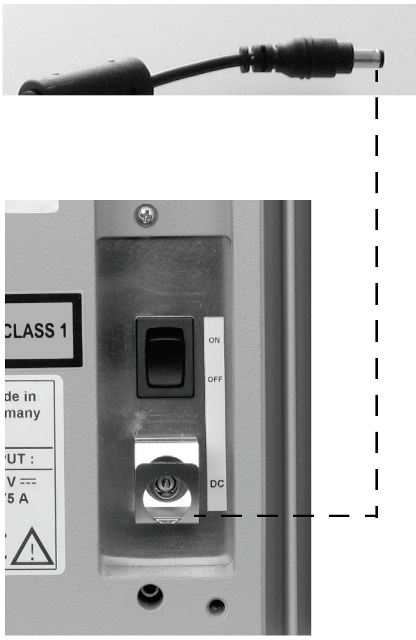
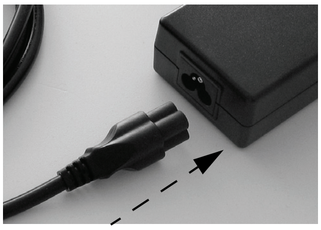
1		Switch off spectrometer. ☞ The switch must be in the "OFF" position.
2		Connect the low-voltage connector to the low-voltage socket located at the rear spectrometer side.
3		Connect the power cord to the C5 socket of the external power supply.

Table 3.6: Connecting spectrometer to power supply when using external power supply unit

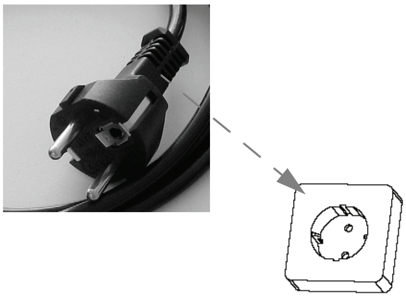
4		Connect the power plug of the power cord to the mains socket outlet. **⚠ CAUTION** **Power plug of the power cord not connected to a socket outlet with earthing contact.** Personal injury ➢ Connect power plug only to a socket with earthing contact. ***NOTE*** **Power plug of the power cord not connected to a socket outlet with earthing contact.** Property damage. ➢ Connect power plug only to a socket with earthing contact.

Table 3.6: Connecting spectrometer to power supply when using external power supply unit

Safety Instructions

To ensure a safe operation of the external power supply unit, observe the following safety instructions:

- Operate the external power supply unit only in a dry environment.
- Make sure that the external power supply unit is not exposed to direct sunlight. Avoid temperatures above +50°C. Ensure that there is sufficient air circulation.
- Properly position the external power supply unit to avoid the danger of tripping over it.
- Do not put heavy objects on the external power supply unit.
- Do not place the external power supply unit on a hot surface.
- If the external power supply unit is damaged disconnect it instantly from the supply circuit. Never put a damaged external power supply unit into operation. Only authorized technicians are allowed to repair the external power supply unit.

3.7 Connecting spectrometer to PC

The spectrometer and the data system are already pre-configured for stand-alone operation by Bruker. For connecting the spectrometer to a stand-alone PC use the standard data cable supplied. It is a crossover cable for 100Base-T Ethernet standard and RJ45 plugs.

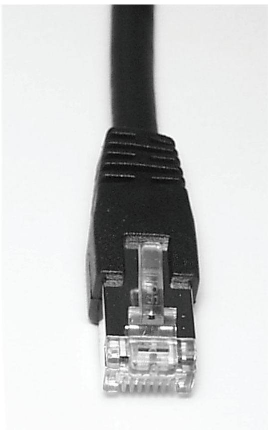


Figure 3.4: CAT-5 data cable with RJ-45 plug

The data cable supplied is determined to be used to directly connect the spectrometer to a stand-alone PC. Other connection topologies are possible which require, however, a different type of data cable.

Procedure

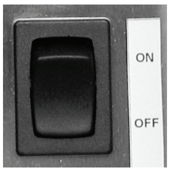
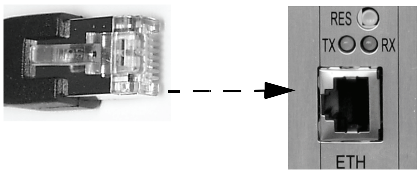
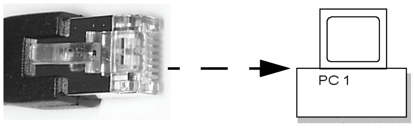
1		The ON/OFF switch must be in the "OFF" position.
2	 	• Connect one end of the cross-over data cable to the ETH port located on the rear spectrometer side. • Connect the other end of the cross-over data cable to the corresponding PC port. For detailed information refer to the computer manual.

Table 3.7: Connecting spectrometer to computer

IP address

The spectrometer IP address has been set to 10.10.0.1 by Bruker. If the delivery content of your spectrometer configuration does not include a PC, you have to assign an appropriate IP address to the type of PC to be used. For detailed information on how to assign an IP address refer to the respective appendix.

3.7.1 System requirements in case of a separate spectrometer PC

If the spectrometer PC has not been acquired with Bruker, the separate spectrometer PC has to meet the following system requirements:

Data system:	• Ethernet, RJ45, 10Base T (10 or 10/100 MHz), USB • Mouse, keyboard • Optionally: Ethernet card for LAN or internet
Processor:	Intel Pentium III, 800 MHz
RAM:	2 GB
Hard disk:	250 GB, IDE
Graphics card:	Intel HD Graphics 2500, 3000, 4000
Monitor:	Resolution: 1024 x 768
Operating system:	• Microsoft Windows 7 (Home Premium or better, 32 bit) • Microsoft Windows XP (Professional 32 bit, Service Pack 3)
Ethernet:	**Windows 7:** • Internet Explorer 9 **Windows XP:** • Internet Explorer 8 **General (for any OPUS version):** • TCP/IP must be configured • Address range of PC network card must include spectrometer IP • Port 80 to spectrometer via network card must be available • No proxy is allowed to interfere with the communication to the optics

Table 3.8: System requirements in case of a separate spectrometer PC

3.8 Connecting spectrometer to accessory

Some Bruker accessories require a power supply via CAN bus.

☞ Connect one end of the CAN bus cable to the particular accessory CAN bus connector.

☞ Connect the other end to one of the CAN bus connectors on the spectrometer rear side (see figure 3.5).

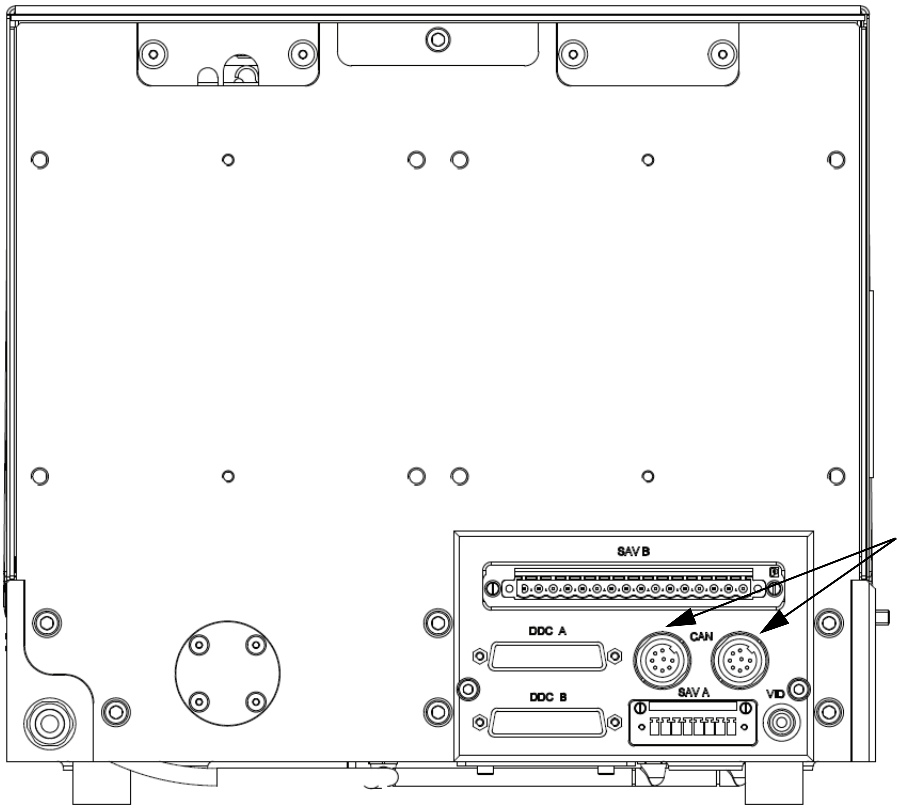


Figure 3.5: Spectrometer rear side with CAN bus connectors

3.9 Installing purge gas supply line

The spectrometer has 3 purge gas circuits for

- the Raman sample compartment
- both interferometer and detector compartment
- the closed FT-IR sample compartment

The purge gas circuits are fed by separate purge gas inlets which are located on the spectrometer rear side.

3.9.1 Purge gas ports on spectrometer rear side

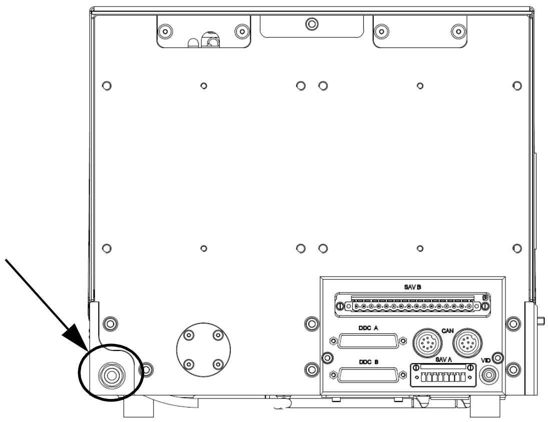
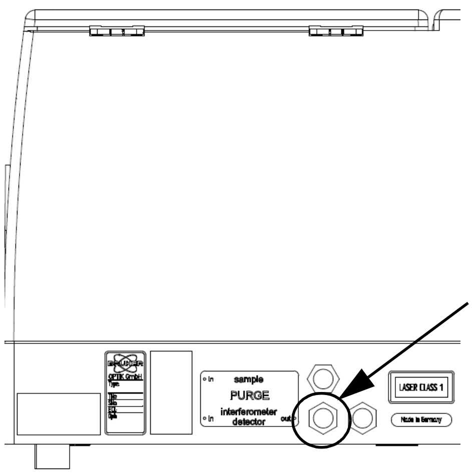
Type of purge gas port	Location on spectrometer rear side
Purge gas inlet for Raman sample compartment	
Purge gas inlet for interferometer and detector compartment	

Table 3.9: Purge gas ports on spectrometer rear side

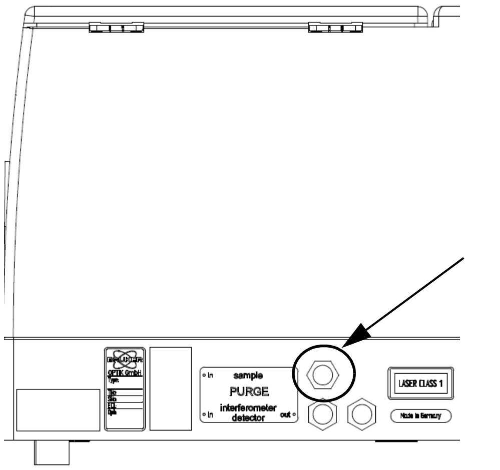
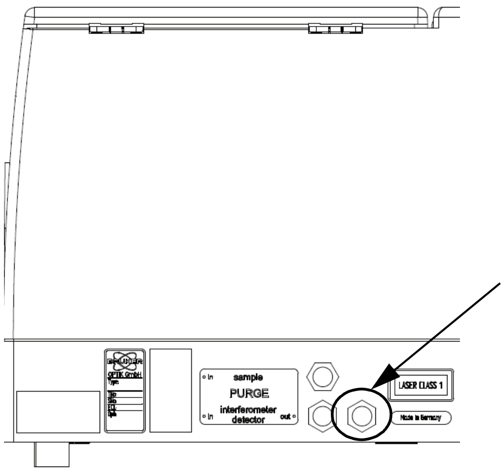
Type of purge gas port	Location on spectrometer rear side
Purge gas inlet for detector compartment when using the optional Ge detector	
Purge gas outlet	

Table 3.9: Purge gas ports on spectrometer rear side

3.9.2 Procedure

☞ To connect the spectrometer to the purge gas supply you need a stiff tube with an outer diameter of 6 mm.

☞ As it is advisable to purge both the Raman sample and interferometer/detector compartment simultaneously, you need 1 cross manifold or 2 T-pieces leading to the spectrometer.

☞ For purge gas supply requirements refer to chapter 5.

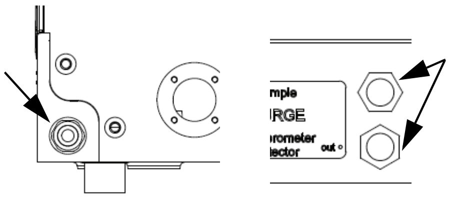
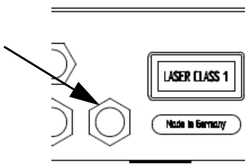
1		Remove the cap from the respective purge gas inlet.
2	**When purging Raman sample compartment:** • Connect one end of the hose to the purge gas supply line. • Insert the other end to the purge gas inlet. **When purging FT-IR sample compartment, interferometer and detector compartment:** • Connect the hose main end to the purge gas supply line. • Insert the other 2 hose ends into the respective purge gas inlets. • Remove the cap from the purge gas outlet (see figure below) to avoid over-pressure inside the spectrometer during purging. 	

Table 3.10: Installing purge gas supply line

3.10 Spectrometer operating phase

After switching on the spectrometer, the spectrometer beeps once and starts a self test. If the spectrometer initialization phase has been completed successfully, the SR LED lights. Now, switch on the computer and the monitor.

For information on how to install the computer and how to set up signal and power cable connections for the computer, monitor etc. refer to the computer manual.

3.11 Spectroscopy software

3.11.1 Installing

In case of initial installation, the spectroscopy software OPUS is installed by Bruker service.

3.11.2 Starting

If the PC has been booted, start the OPUS spectroscopy software which has been pre-installed on the PC. More details on the software are described in the OPUS Reference Manual.

4 Description

This chapter describes all relevant spectrometer compartments. Depending on the spectrometer configuration your instrument may look slightly different.

i The local indications right and left assume that the operator stands in front of the spectrometer. The same applies to the indication front and rear side, respectively.

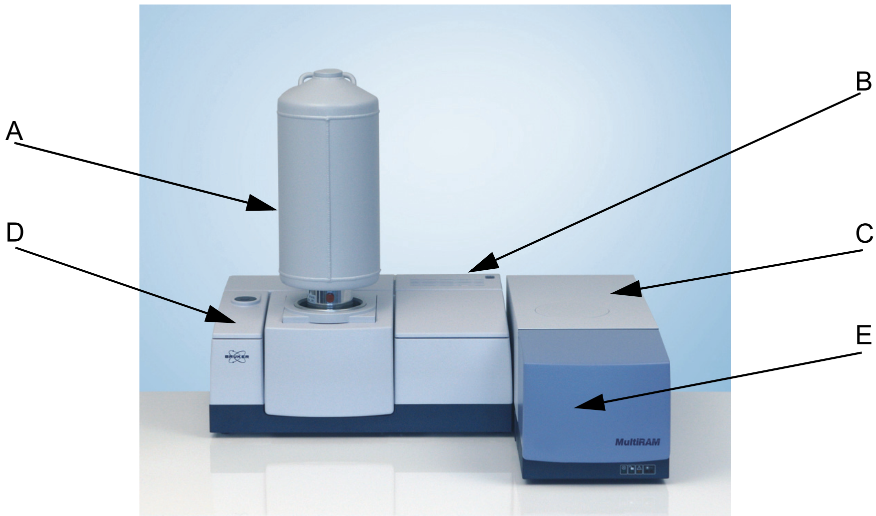


Figure 4.1: MultiRAM - External view

	Definition
A	Ge detector (optional)
B	Electronics compartment
C	Optics compartment
D	Detector compartment
E	Sample compartment

Table 4.1: MultiRAM - Definition of spectrometer components

In the standard configuration MultiRAM provides a spectral range of up to 3,500 cm^{-1} (Stokes shift). By default, the beam of the Raman laser can be focused or defocused.

The diameter of the focused beam is about 100 µm, the one of the defocused beam is about 1 mm. The defocused beam is used for sensitive samples, or to avoid heating effects. To achieve maximum sensitivity use the focused beam.

Different types of motorized sample stages as well as vertical and horizontal sample holders can be mounted in the sample compartment to optimize the sample position.

The spectrometer can be equipped with either or both an InGaAs detector and a proprietary high-sensitivity liquid-nitrogen cooled Ge detector.

4.1 Status indicators

The status indicators generally indicate

- the air humidity level inside the spectrometer
- the operating status of the laser and
- the general spectrometer status

In case of a spectrometer problem, the status indicators facilitate the fault diagnostics.

By means of these status indicators at the front of the Raman sample compartment and on the electronics compartment cover, it is possible to permanently monitor the current status of different MultiRAM components.

4.1.1 Located on the front side of the Raman sample compartment

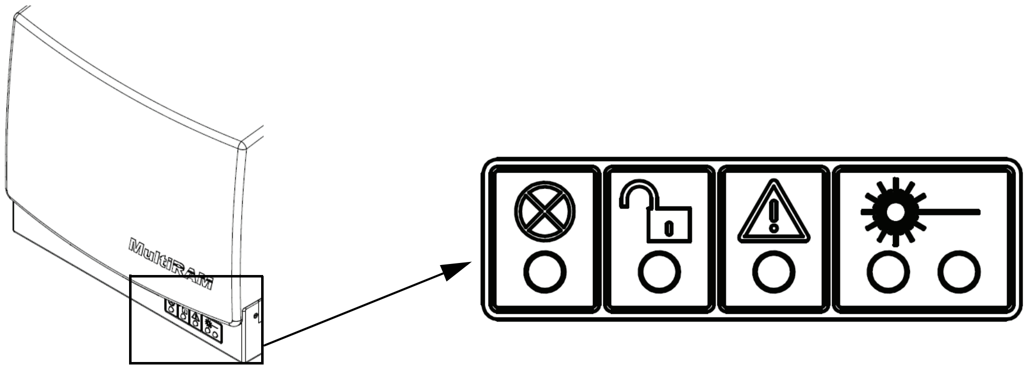


Figure 4.2: MultiRAM - Status indicators located on the front side of the Raman sample compartment

i Make sure that the LEDs always work properly. In case of failure, contact Bruker service and have the entire status indicator LED block replaced (see chapter 6.3).

4.1.1.1 Definition of status indicators

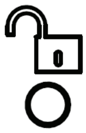
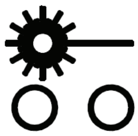
Status indicator	Definition
	**Status of reference lamp** It indicates whether the reference lamp is active or not. • Green = ON • Black = OFF
	**Interlock status** It refers to the safety interlock system in the sample compartment. • Yellow = interlock activated, sample compartment lid open • Black = interlock deactivated, sample compartment lid closed
	**Error status** It refers to the laser system, and the LED lights as soon as the laser does not operate properly. • Orange = laser system error • Black = laser system okay
	**Laser status (Raman)** For safety reasons this kind of indicator has two LEDs which are both on or off. If one LED fails, the other will still indicate the laser status of the lasers in the optics compartment. • Red = Laser is ON • Black = Laser is OFF

Table 4.2: Definition of status indicators located on the front side of the Raman sample compartment

4.1.2 Located on the cover of the electronic compartment

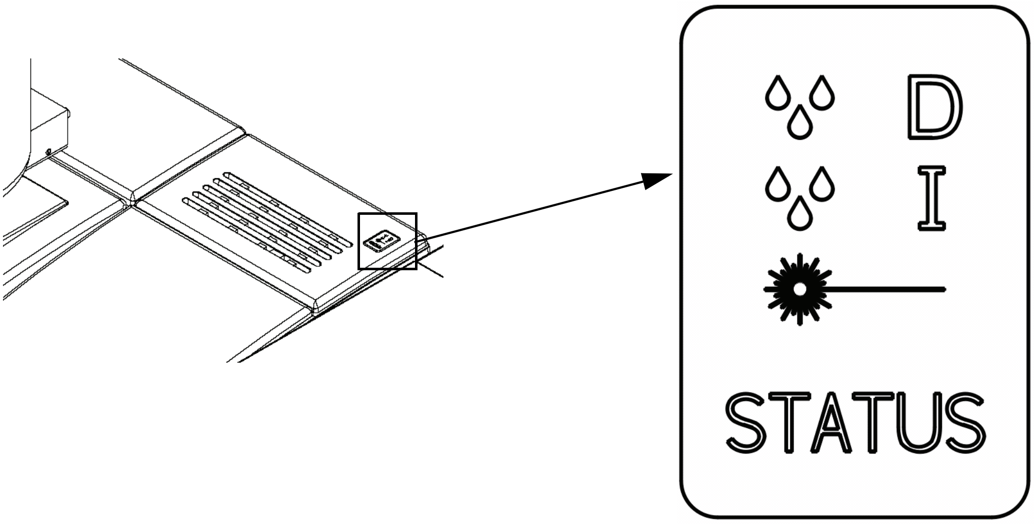


Table 4.3: MultiRAM - Status indicators located on the cover of the electronic compartment

4.1.2.1 Definition of status indicators

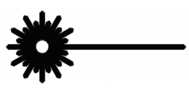
Status indicator	Definition
	**Humidity status - Detector compartment** This status indicator is deactivated with MultiRAM.
	**Humidity status - Interferometer compartment** This status indicator is deactivated with MultiRAM.
	**Laser status (HeNe)** It indicates whether the laser operates or not. • Orange = laser operates • Black = no laser operation, power supply to laser is interrupted
	**General status** It indicates the general spectrometer status. • Red = spectrometer initializes, or spectrometer malfunction occurred • Green = spectrometer is in proper operating condition

Table 4.4: Definition of status indicators located on the cover of the electronic unit

4.2 Raman sample compartment - Exterior view

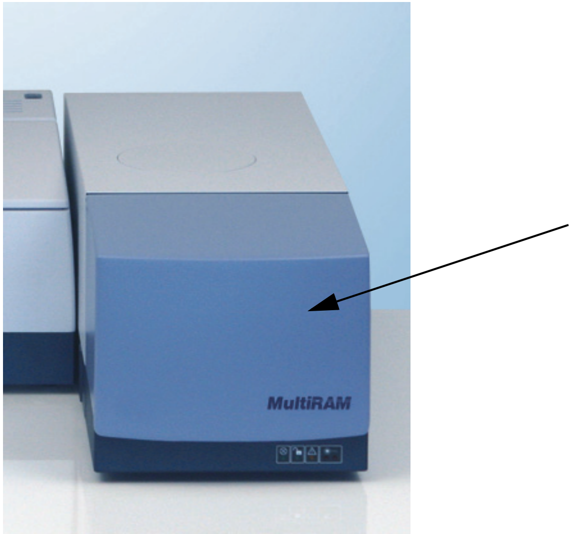


Figure 4.3: MultiRAM - Raman sample compartment (exterior view)

The spectrometer has a large front-mounted sample compartment to provide unlimited access from three sides.

4.3 Raman sample compartment - Interior view

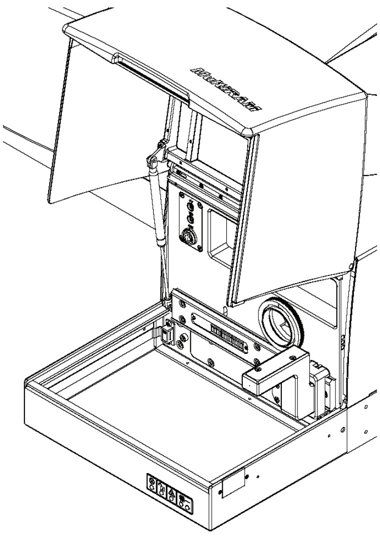


Figure 4.4: MultiRAM - Raman sample compartment (interior view)

To lift the sample compartment lid reach under the bottom edge of the light blue cover. Open the sample compartment only to prepare sample measurements and to perform maintenance. For details on maintenance, see chapter 6.

4.3.1 Connectors

The connectors are located on the top left side of the Raman sample compartment.

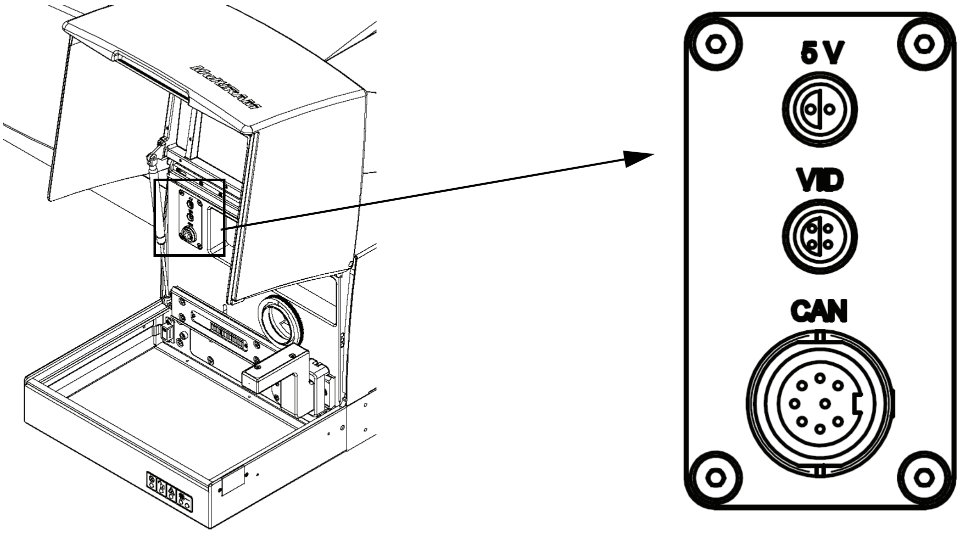


Figure 4.5: MultiRAM - Connectors in the Raman sample compartment

4.3.1.1 Definition of connectors

Connector	Definition
	Connector for reference lamp
	Connector for the R-348-VA video accessory
	CAN bus connector for conventional sample stage

Table 4.5: Definition of connectors located in the Raman sample compartment

4.3.2 Reference lamp

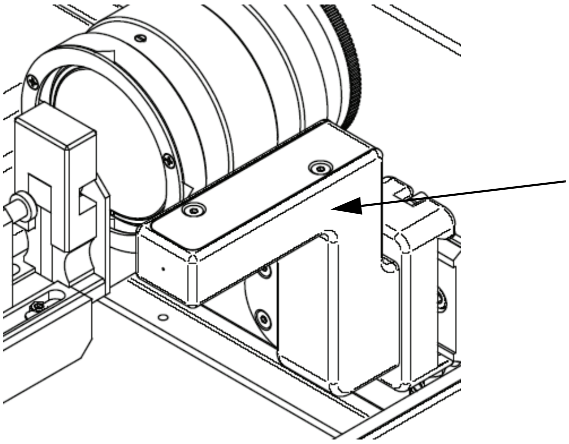


Figure 4.6: MultiRAM - Reference lamp

The reference lamp is integrated into the sample compartment, and emits light on a Spectralon sample which is used for reference measurement. This kind of lamp is used to calibrate the y-axis.

If there is little or no Raman signal, the reference lamp can be used as a signal source to check the interferometer alignment or the spectrometer ZPD (Zero Path Difference). Additional information on the reference lamp are provided in chapter 5.9 and F.7 et seq.

4.3.2.1 Switching on and off reference lamp

The reference lamp is switched on/off by the OPUS spectroscopy software.

1. On the OPUS *Measure* menu, select the *Advanced Measurement* command.
2. Click the *Optic* tab.
3. From the *Source Setting* drop-down list, select the *Reference Lamp* option.

4.3.3 Sample stage

Sample stages used in connection with MultiRAM are pre-aligned, i.e. only the Z-axis can be adjusted to set the sample to the appropriate sample position.

i After switching on or off the spectrometer, or after inserting a different stage type, the stage must be reset to the zero or home position by the OPUS/MAP spectroscopy software.[1] After switching on the spectrometer the stage type is recognized by the software. To move the stage you have to use OPUS/MAP.

1. In the OPUS/MAP manual, the resetting procedure is described by means of the *Calibrate stage* button.

4.3.3.1 FT-Raman mapping (XY) stage

The FT-Raman mapping stage is used to analyze TLC (Thin Layer Chromatography) plates or other flat samples, e.g. paper and textiles. This kind of sample stage is moved in x and y direction by the spectroscopy software OPUS. The axis parameters x and y define the movement direction of the stage, horizontally to the left/right (x) and to the front/back (y). More details are described in the OPUS/MAP manual.

The stage requires a high throughput mirror objective (R348 or R348-VA) to achieve optimum sensitivity and to redirect the laser beam onto the horizontal sample arrangement.

4.3.3.2 Motorized XYZ-stage

The motorized XYZ-stage is either used for point-by-point mapping applications, or to optimize sample positioning. This kind of stage includes easy operating features for solid and liquid samples, and a pre-alignment unit for powdered samples.

The motorized XYZ-stage is moved in x, y and z direction by the spectroscopy software OPUS. The axis parameters x and y and z define the movement direction of the stage, horizontally to the left/right (x) and to the front/back (y) as well as vertically (z). More details are described in the OPUS/MAP manual.

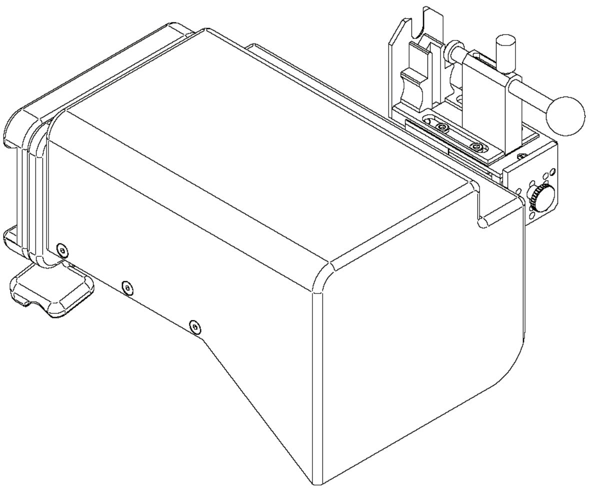


Figure 4.7: Motorized XYZ-stage

4.3.3.3 HTS sample stage

The HTS sample stage is used to analyze microtiter plates in standard format. A high throughput mirror objective is used. The plates are analyzed from below.

For measurements of samples being applied on a 96-well microtiter plate, the stage movement is controlled by the spectroscopy software OPUS/LAB. After a measurement series has been defined and started in OPUS/LAB, the stage moves automatically from one predefined measurement position on the microtiter plate to the other. More details are described in the OPUS/LAB manual.

4.3.3.4 Temperature-controlled sample stage

This kind of sample stage (Linkam stage) allows temperature-controlled sample analysis. The stage is designed for both heating and freezing a sample. Temperatures above ambient temperature are realized by a connected temperature controller (Eurotherm). For detailed information refer to the supplied Eurotherm documentation.

Temperatures below ambient temperature are achieved by pumping liquid nitrogen through the heating/cooling block of the stage. For detailed information refer to the supplied Linkam documentation.

When fixing the temperature-controlled sample stage inside the sample compartment the cover plate on the right side of the sample compartment lid has to be removed. More details on this subject are described in chapter 11.8.

4.3.4 Collecting lens assembly

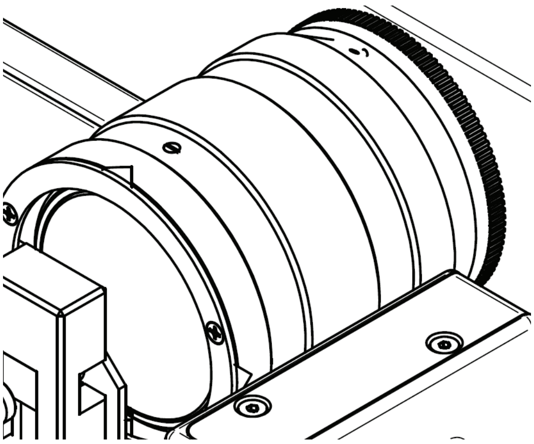


Figure 4.8: MultiRAM - Collecting lens assembly

The collecting lens assembly consists of an AR-coated aspheric lens fixed in a mechanical mount. In the standard configuration MultiRAM uses the R352/R objective, with a working distance of 16 mm.

It is possible to use a collecting lens assembly with a different focal length and working distance.

4.3.4.1 Options

- R348/R (mirror objective with parabolic mirror for samples in horizontal position)
- R348VA video accessory

The R348VA video accessory directly displays an image of the sample on the PC screen. It allows to view the sample which is mounted on a horizontal sample stage with the sample compartment being closed. Both the laser incidence on the sample and the sample itself can be seen simultaneously.

The video accessory consists of a CCD camera which is attached to a mirror objective with a focal length of 33 mm, a Framegrabber and the possibility to illuminate the sample.

4.3.4.2 Removing collecting lens assembly

i If a sample stage is still mounted in the sample compartment, dismount the stage only AFTER removing the collecting lens assembly to avoid possible damages on the lens.

1. Turn the mounting ring of the assembly clockwise until the red points match.
2. Pull out the lens from the holder.

4.3.4.3 Inserting collecting lens assembly

1. Make sure that the red assembly point is in line with the red point located in the sample compartment.
2. Turn the ring counter-clockwise to secure the lens assembly.

4.4 Optics compartment - Exterior view

The optics compartment is located on the right spectrometer side.

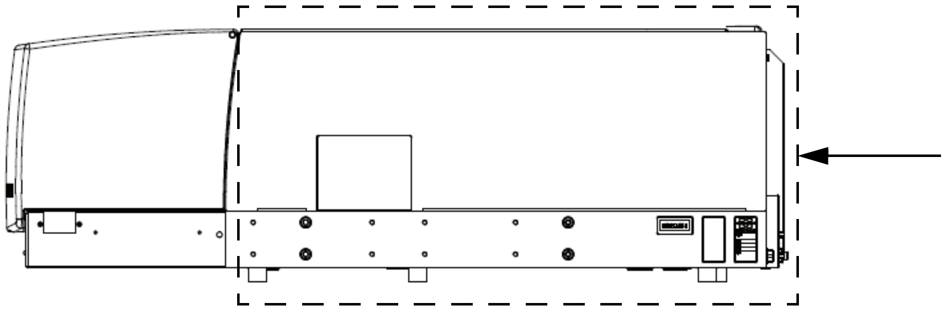


Figure 4.9: MultiRAM - Optics compartment

4.5 Optics compartment - Interior view

The optics compartment integrates laser(s), filter systems, detectors, adjustment lamp, mirrors and polarizers. Due to the construction of the optics compartment with redundant interlocks, it is ensured that no laser light emits from this compartment.

When the MultiRAM spectrometer is delivered, all the optics components have already been pre-aligned and do not need to be maintained. In case of any defective optical components contact Bruker service.

4.5.1 Laser

The laser is located at the back of the spectrometer. During normal spectrometer operation (when all covers are closed) the MultiRAM optics is not accessible and no laser radiation emits. That is why the entire spectrometer is a Laser Class 1 product.

i Do not operate the spectrometer if the sample compartment covers are removed or damaged.

The spectrometer is equipped with the following laser types:

- Raman laser
- HeNe laser

4.5.1.1 Raman laser

The Raman laser is completely software controlled and emits high intensity radiation.

- Laser class 4 (according to EN60825-1:2007)

The wavelength and rated output may vary as follows:

- 1064 nm, maximum rated output: 500, 1000 or 2000 mW
- 785 nm, maximum rated output: 500 mW

The laser radiation is directed from the optics baseplate to the front-mounted sample compartment. The *Laser* status indicator (figure 4.2 on page 38), at the front of the Raman sample compartment, indicates the laser operating status.

The spectrometer uses two redundantly working interlock systems (safety shutters) which monitor and scan the position of the sample compartment lid. If the Raman sample compartment lid is open, these two interlock systems are activated, and the safety shutters block the Raman laser beam.

Only after closing the Raman compartment is the laser beam immediately unblocked, and the laser can be controlled by the measuring software. Thus, measuring is only possible if the laser beam does not emit at all or only selectively, e.g. at the aperture of the measuring probe.

4.5.1.2 HeNe laser

- Wavelength: 633 nm
- Rated output: 1 mW
- Laser class 2 (according to EN60825-1:2007)

The HeNe laser controls the position of the moving interferometer mirrors (scanner) and is used to determine the data sampling positions. The monochromatic beam produced by the HeNe laser is modulated by the interferometer to generate a sinusoidal signal.

A defective HeNe laser needs to be replaced. Replacing a defective HeNe laser is done by Bruker service.

4.5.1.3 Boxes for laser safety

The spectrometer configuration can be extended or complemented. Due to this kind of retrofitting the classification of the entire system may change. To ensure laser safety different types of laser boxes are available depending on the laser class applied:

- LK1 box: for laser class 1
- LK 3B/4 box: for laser class 3B or 4

LK1 box

Important: In case of Raman systems belonging to laser class 1, the laser radiation is NOT accessible to the user. Special precautions are not necessary with laser systems of laser class 1, according to EN 60825-1:10-2007.

The laser safety box LK1 is used with the following spectrometer configuration:

- MultiRAM with RamanScope III

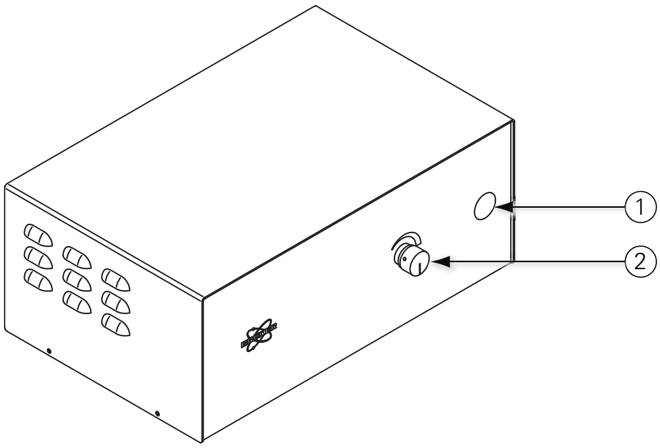


Figure 4.10: Laser safety box LK1 - Front side

Pos. no.	Definition
1	On/Off push button (only applicable with SENTERRA)
2	Illumination control: sets the VIS illumination (light spot on the sample stage) of the RamanScope III

Table 4.6: Components of laser safety box LK1 - Front side

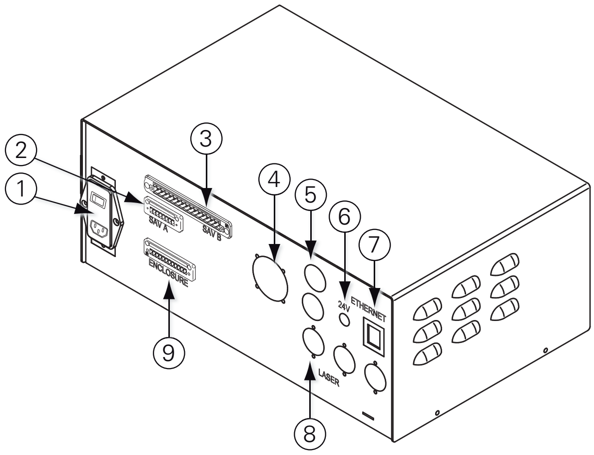


Figure 4.11: Laser safety box LK1 - Rear side

Pos. no	Definition
①	Disconnecting device (on/off switch and female connector for main power supply)
②	SAV A: Spectrometer connector
③	SAV B: Spectrometer connector
④	Ventilation slot
⑤	Cable outlet ports
⑥	24 V connector
⑦	ETHERNET: Network connector
⑧	LASER: Connector for laser safety cable
⑨	ENCLOSURE: Connector for laser protective enclosure

Table 4.7: Components of laser safety box LK1 - Rear side

LK 3B/4 box

ℹ Important: In case of Raman systems belonging to laser class 3B or 4 the laser radiation is accessible to the user. According to EN 60825-1:10-2007 special precautions need to be observed!

The laser safety box LK3B/4 is used with the following spectrometer configurations:

- MultiRAM with RamanScope III and fiber-optical probes
- MultiRAM with fiber-optical probes

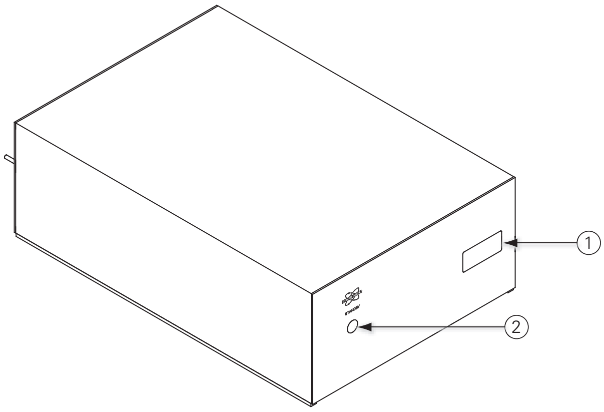


Figure 4.12: Laser safety box LK3B/4 - Front side

Pos. no	Definition
1	Display
2	Status indicator (not available with MultiRAM)

Table 4.8: Components of laser safety box LK3B/4 - Front side

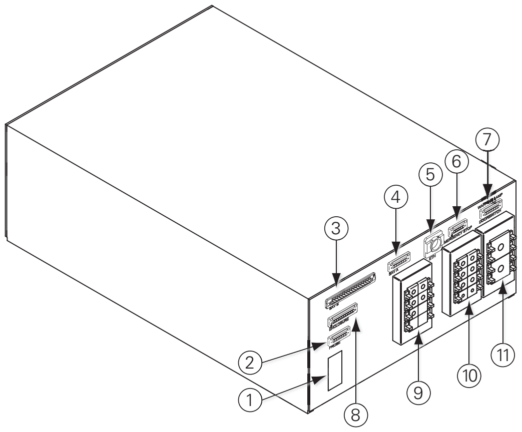


Figure 4.13: Laser safety box LK3B/4 - Rear side

Pos. no	Definition
1	Disconnecting device (on/off switch and main supply socket)
2	PROBE: Probe connector
3	SAV B: Spectrometer connector
4	SAV A: Spectrometer connector
5	ETH: Network connector
6	EMERGENCY STOP: Connector for emergency switch
7	WARNING LAMP/DOOR SWITCH: Connector for external warning lamp and magnetic switch within the safety door frame
8	ENCLOSURE: Connector for laser protective enclosure
9	Connector for laser safety cable
10	Optional connectors
11	Optional connectors

Table 4.9: Components of laser safety box LK3B/4 - Rear side

Control box

This control box is exclusively used to control the laser safety box LK3B/4, and to activate and block the laser beam of the spectrometer.

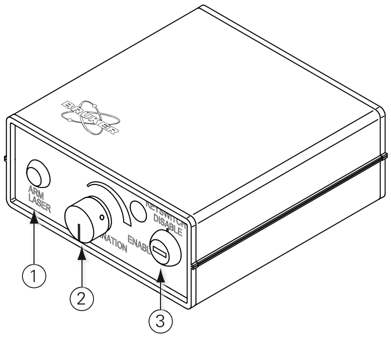


Figure 4.14: Control box - Front side

Pos. no.	Definition
①	**Armed laser button** When operating Raman systems belonging to laser safety class 4, pressing this button enables the laser beam.
②	**Illumination control** The illumination control sets the VIS illumination (light spot on the sample stage) of the RamanScope III.
③	**Key-operated switch** Turning the appropriate safety key activates the internal laser beam shutter. ℹ The laser beam is blocked when the safety key is pulled out from the key-operated switch.

Table 4.10: Components of control box

4.5.2 Filter

A pre-aligned Rayleigh filter blocks the dominant elastically-scattered light before it is passed to the detector, allowing the weaker Raman spectrum to be recorded.

4.5.2.1 Options

- Filter system to filter the exciting laser radiation, and to suppress laser radiation mixed into the Raman signal; the system is available for the wavelengths of 1064 and 785 nm
- Filter system to suppress thermal radiation within a certain wavelength range
- Analyzing polarizer in 0° and 90° excitation

4.5.3 Detector

The spectrometer can be equipped with up to 2 internal and 1 external detector. All 3 detector positions are accessible. The two internal detectors are accessible from outside and can be replaced (chapter 6.4), if defective.

All detector types used in connection with MultiRAM are electronically coded, enabling the spectrometer firmware to auto-detect the detector type currently installed. The data detected on the detector type are transferred to the OPUS application software.

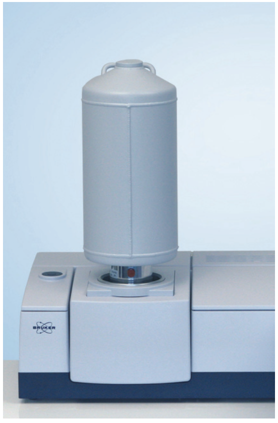
4.5.3.1 Internal detector types

Detector type	Description
InGaAs diode	• dovetail-mounted InGaAs diode detector with an integrated pre-amplifier • operates at room temperature • cryogens for cooling are not required
Si avalanche	• dovetail-mounted Si avalanche diode detector (D518/R) with an integrated preamplifier, and an internal Peltier cooler with a high voltage module • operates at room temperature • thermoelectrically cooled and uses the DigiTect technology i To be able to use this detector type the spectrometer has to be equipped with 2 lasers.

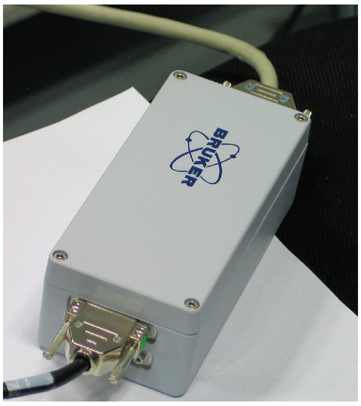
Table 4.11: Internal detector types

4.5.3.2 External Ge-detector

The spectrometer can optionally be equipped with a Ge detector. A conversion unit (detector box) is used to connect this detector type to the spectrometer.



Ge detector



Detector box

Figure 4.15: Ge detector elements

This detector is especially designed for low light level applications. The detector and pre-amplifier are cooled by liquid nitrogen for optimum sensitivity. In order to reduce effects of stray light, the window of the detector dewar only transmits radiation below 11,750 cm $^{-1}$.

For proper operation of the FT-Raman spectrometer, make sure that no other light than Raman radiation reaches the detector element.

The liquid-nitrogen cooled Ge detector is delivered with an ultra long 5-day hold time dewar to allow the system to be more adaptable to applications which require long- term unattended operation. See chapter 5.7 on how to refill Ge detectors with liquid nitrogen.

In case of strong Raman scattering, both InGaAs and Ge detectors provide comparable signal-to-noise ratios. Whereas in case of weaker scattering or low throughput measurements, the Ge detector can deliver up to 3 to 5 times better a signal-to-noise ratio and thus speed up analysis time and improve detection limits.

4.5.4 Adjusting lamp

To locate the sample position illuminated by the laser the spectrometer is equipped with an adjusting lamp.

4.6 Optical path

Figure 4.16 shows the optical path of the MultiRAM spectrometer.

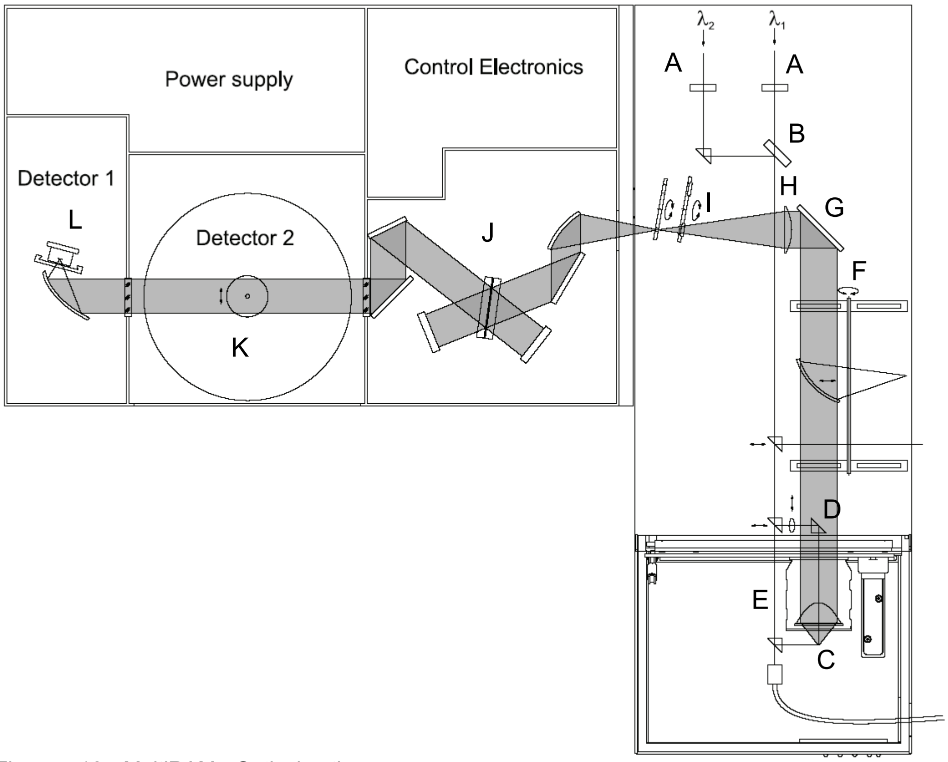


Figure 4.16: MultiRAM - Optical path

	Component		Component
A	Half waveplate	G	Mirror
B	Dielectric mirror	H	Lens
C	Sample	I	Filter wheel
D	180° sample excitation	J	Beamsplitter
E	90° sample excitation	K	Detector (option)
F	Cut-off filter	L	Detector (standard)

Table 4.12: Components of optical path

Laser light emits from the installed laser type, passes an optional half waveplate (A) with a software-controlled rotation unit, and can hit an optional dielectric mirror (B). If two lasers are installed, this dielectric mirror transmits the first laser wavelength and reflects the second laser wavelength by different prisms to the sample (C).

i The standard configuration includes a 180° (D) excitation of the sample, whereas the optional 90° excitation (E) can be activated by software control.

The Raman light is collected by a lens and filtered by a cut-off filter (F). In case of more than one wavelength excitation the cut-off filter (F), which filters the laser wavelength, is assembled on a rotatable wheel. From the mirror (G) the light travels through a lens (H) to the beam entry port.

The modulated IR light is directed from the entry port to the beamsplitter (J). The beam-spitter directs the light to the detector (L) or to the optional detector (K).

5 Operation

If the spectrometer has been configured and connected to the PC you can start acquiring data. The spectrometer is completely software controlled, i.e. many components (e.g. detector) are selected and controlled by using the OPUS software. For details about the software and how to perform a data acquisition refer to the OPUS Reference Manual.

This chapter describes the spectrometer-related aspects of operation. For information on software-related aspects (e.g. parameter setting and data acquisition), refer to the OPUS software Reference Manual.

Before starting routine operation we recommend running an OVP (OPUS Validation Program) test. OVP is an application software which is part of OPUS and allows an automated validation of the spectrometer for the Performance Qualification Test (PQ[1]) and Operational Qualification Test (OQ[2]). For details refer to the OPUS Reference Manual.

5.1 Operating safety

During operation the spectrometer generates laser radiation and high voltages in some of the electronics.

⚠ CAUTION

Spectrometer covers removed

Laser and source radiation could be emitted and cause health hazards and property damage. The spectrometer‘s optics may be contaminated.

➢ Always keep the spectrometer covers closed and secured during operation.

NOTE

Objects placed on spectrometer

Objects may fall inside and damage spectrometer components when any of the compartment covers is removed.

➢ Do not place any object on top of the spectrometer.

1. Qualification of spectrometer performance in daily routine work
2. Qualification of spectrometer performance after installation or maintenance

5.2 Switching spectrometer on and off

The spectrometer is turned on and off by the main power switch located on the spectrometer rear side.

Status	Setting
On	Main power switch must be in the "ON" position
Off	Main power switch must be in the "OFF" position

Table 5.1: Switching spectrometer on and off

After powering up the spectrometer, laser light is generated inside the spectrometer. A self-test cycle starts automatically and takes about 30 seconds. If the test has been passed successfully, the STATUS indicator (chapter 4.1) turns form red to green.

i After powering up the spectrometer wait at least 10 minutes before starting with the first measurement. This allows the electronics to stabilize.

5.3 Positioning accessory into Raman sample compartment

The Raman sample compartment is equipped with the QuickLock mechanism for positioning and locking different measuring accessories, provided the accessory is equipped with a QuickLock baseplate.

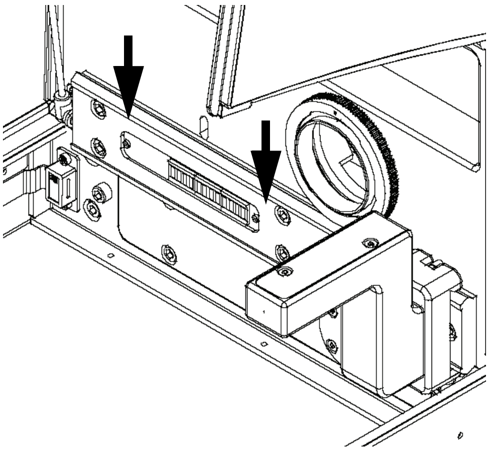
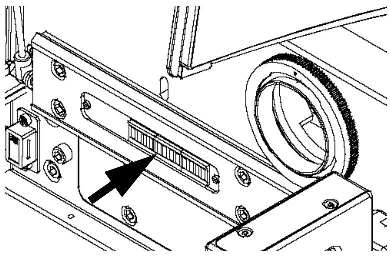
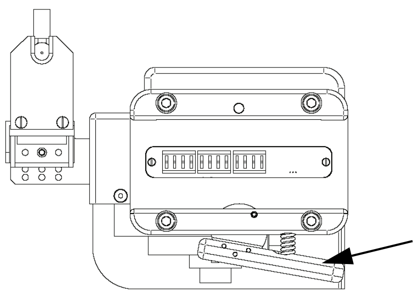


Figure 5.1: MultiRAM - QuickLock mechanism in the Raman sample compartment

If the accessory has been inserted and locked, all connections are established and the accessory is automatically identified by the OPUS application software, i.e. by the AAR software (Automatic Accessory Recognition).

Procedure

<table>
<tr><td>1</td><td colspan="2">Open the sample compartment lid.
➣ The Interlock status LED (chapter 4.1.1.1), which is located on the spectrometer front side, is yellow. The interlock is activated.
➣ The two Laser LEDs (chapter 4.1.1.1), which are located on the spectrometer front side, are off. The laser is off and laser radiation cannot emit.</td></tr>
<tr><td>2</td><td colspan="2">Insert the accessory into the Raman sample compartment with the QuickLock baseplate front edge slightly tilted upwards.</td></tr>
<tr><td>3</td><td></td><td>Gently push the electrical baseplate connectors against their counterpart of the QuickLock fixture in the sample compartment.</td></tr>
<tr><td>4</td><td colspan="2">Put the baseplate down.
☞ The baseplate must be horizontally aligned to the QuickLock fixture.</td></tr>
<tr><td>5</td><td></td><td>Gently apply downward pressure to the front edge of the baseplate until the baseplate snaps into its correct position.

ℹ To facilitate the insertion of the accessory, press the accessory release lever (marking in figure) backwards.</td></tr>
</table>

Table 5.2: Positioning accessory into Raman sample compartment

5.4 Removing accessory from Raman sample compartment

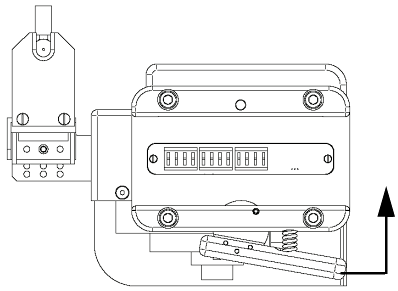
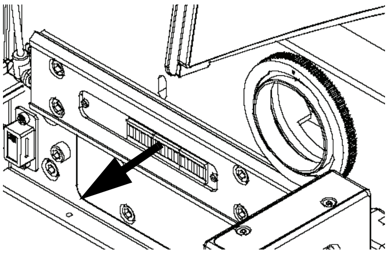
1	Open the sample compartment lid. ➢ The *Interlock* status LED (chapter 4.1.1.1), which is located on the spectrometer front side, is yellow. The interlock is activated. ➢ The two *Laser* LEDs (chapter 4.1.1.1), which are located on the spectrometer front side, are off. The laser is off and laser radiation cannot emit.	
2		Push the QuickLock accessory release lever (marking in figure) upwards.
3	Lift the front edge of the QuickLock baseplate until the baseplate snaps free.	
4		Carefully pull off the baseplate from the QuickLock fixture. ☞ Be careful to avoid damage to the electrical connectors on the baseplate rear side.

Table 5.3: Removing accessory from Raman sample compartment

5.5 Installing external Ge detector

The spectrometer standard configuration is equipped with a room temperature controlled InGaAs detector.

If you work with an advanced spectrometer configuration and the measurement requires a different spectral range or different detector sensitivity, you can install an external Ge detector. Further details on the detector types available for the spectrometer are described in chapter 4.5.3.

Delivery content

- Ge detector
- Detector box (converting unit)
- 2 connecting cables
- Detector pod
- Plastic cover
- Plastic cap

Procedure

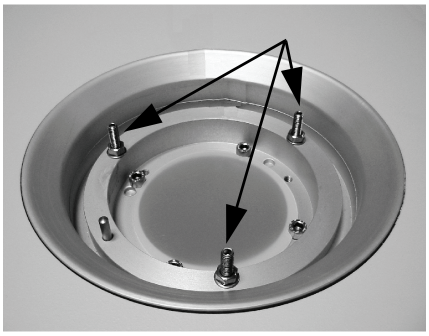
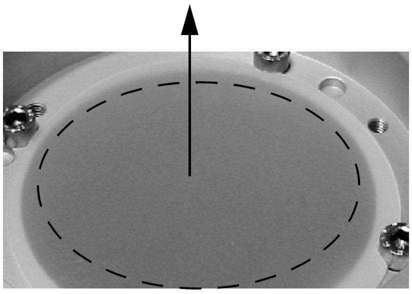
1		Screw off the 3 nuts from the socket screws. The nuts are located on the detector inlet port on top of the accessory module.
2		Remove the plastic cover from the detector inlet port.
3	• Carefully insert the detector into the detector inlet port. • Gently push the detector downwards until it locks into place.	

Table 5.4: Installing external Ge detector

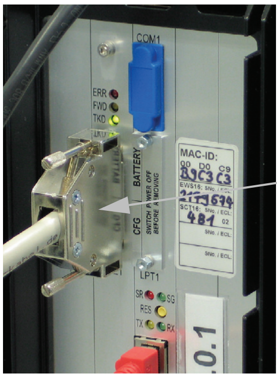
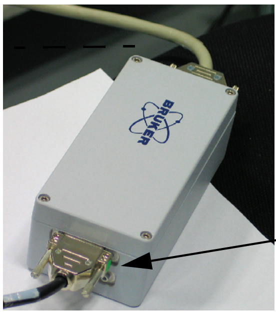
4		Connect one end of the white 25-pin connecting cable to the MPE1 port, located on the spectrometer rear side.
5		Connect the other end of the white 25-pin connecting cable to the left port, located on the detector box.
6		Connect one end of the black 15-pin connecting cable to the POWER port, located on the Ge detector rear side.
7		Connect the other end of the black 15-pin connecting cable to port 1, located on the detector box.
8	➢ A beep indicates that the electrical connection has been established. • In OPUS, check whether a signal is detected and the optics works correctly. ➢ For detailed information, refer to the OPUS Reference Manual.	

Table 5.4: Installing external Ge detector

5.6 De-installing external Ge detector

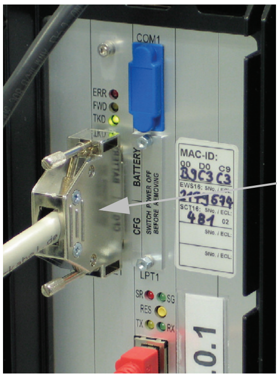
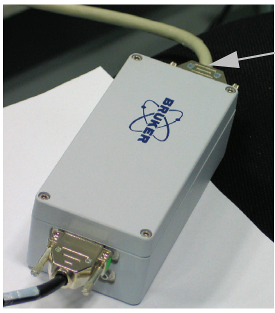
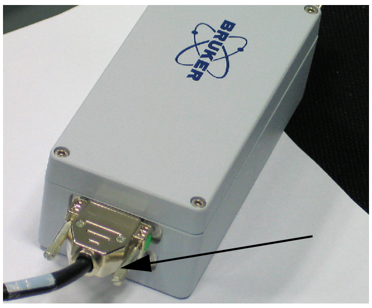
1		Disconnect one end of the white 25-pin connecting cable from the MPE1 port, located on the accessory module rear side.
2		Disconnect the other end of the white 25-pin connecting cable from the left port, located on the detector box.
3		Disconnect one end of the black 15-pin connecting cable to the POWER port, located on the Ge detector rear side.
4		Disconnect the other end of the black 15-pin connecting cable to port 1, located on the detector box.

Table 5.5: De-installing external Ge detector

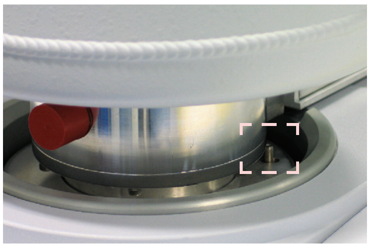
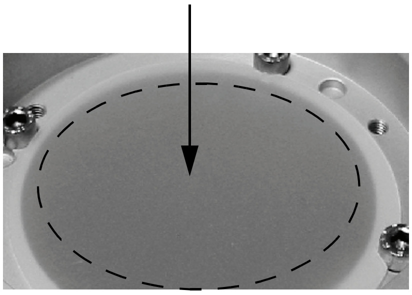
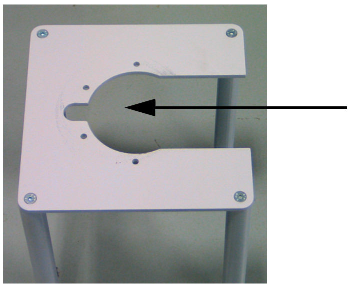
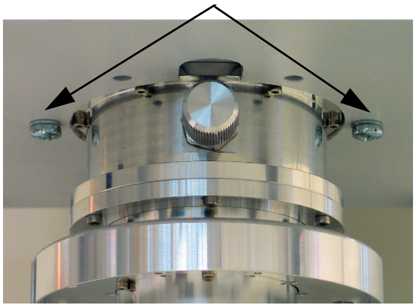
5		➢ There are 3 headless screws at the detector positioning. • Remove the nuts from these 3 headless screws. • Pull out the detector straight upwards from the inlet port. Be careful not to cause any damage on the mirrors.
6		• Put the plastic cover onto the detector inlet port again. • Screw the nuts onto the headless screws again.
7		Place detector in upright position onto the detector pod supplied.
8		Fasten the two fixing screws on the bottom side of the detector pod.

Table 5.5: De-installing external Ge detector

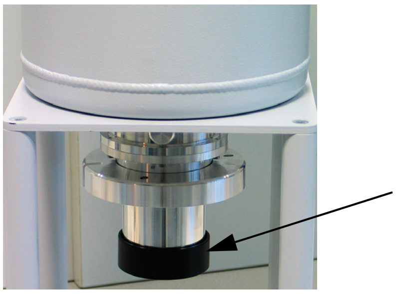
9		Cover the detector window by the black plastic cap to protect the window from dust and other contaminants.

Table 5.5: De-installing external Ge detector

5.7 Cooling Ge detector

Spectrometer configurations equipped with the optional Ge detector require liquid nitrogen to be filled into a dewar for cooling the detector. Standard detectors require no cooling by liquid nitrogen.

Hold time[a]:	depends on the spectrometer type ➢ The Ge detectors supplied have a hold time of 5 days.
Delivery content of detector:	protective dewar plug
Cooling medium required:	liquid nitrogen
Cooling volume required:	between 2 l/day and 7.5 l/5 days
Indications of a weakening cooling effect:	• decreased signal intensity • no signal at all • OPUS status light becomes red • instrument status message in OPUS reads: *Detector not ready*. • Detector diagnostics icon in OPUS: 

Table 5.6: Details on cooling detector

a. Hold time: indicates how long the cooling effect of the liquid nitrogen will last

⚠ CAUTION

Improper use of liquid nitrogen

Can cause frostbites, damage to eye tissue, and asphyxiation

➢ Avoid any skin contact.

➢ Always wear face shields or safety goggles.

➢ Use liquid nitrogen only in well-ventilated rooms.

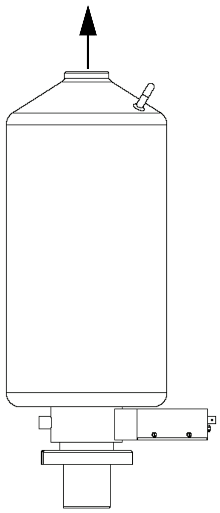
➢ Observe the safety instructions described in chapter 5.7.1.

5.7.1 Safety instructions to be observed when working with liquid nitrogen

Avoid skin contact:	Due to the extremely low temperature of liquid nitrogen (-196°C), any skin contact can cause severe frostbites.
Avoid spillage of liquid nitrogen:	When spilled on a surface, liquid nitrogen tends to cover the entire surface and cools it immediately.
Rooms need to be well ventilated:	• To be able to prevent excessive nitrogen gas concentrations from being available, as excessive nitrogen gas concentrations in the air reduce the concentration of oxygen and can cause asphyxiation. • Nitrogen gas is colorless and tasteless, and thus cannot be detected by human senses. • As nitrogen gas is odorless there is the risk of being inhaled as if it were normal air.
Wear face shield or safety goggles:	• The sensitive eye tissue can be damaged if exposed to this cold gas, even if exposed for a short period of time. • Use only safety goggles with side shields.

Table 5.7: Safety instructions to be observed when working with liquid nitrogen

5.7.2 Cooling procedure

<table>
<tr><td>1</td><td></td><td>Remove the protective cap from the detector dewar.</td></tr>
<tr><td>2</td><td colspan="2">Slowly fill in liquid nitrogen into the detector filling port.

i At the beginning, when the temperature difference between detector dewar and liquid nitrogen is still very large, the liquid nitrogen will evaporate and escape.

⚠ WARNING
Cold nitrogen filled into warm container:
Nitrogen boils and splashes. Risk of frostbites.
➢Fill in nitrogen slowly into the container.
➢Keep away from boiling and splashing nitrogen, and its escaping gases.</td></tr>
<tr><td>3</td><td colspan="2">• Wait before refilling.
➢ If the liquid nitrogen does not escape any more, the dewar has cooled down to the liquid nitrogen temperature.
• Fill the dewar again with liquid nitrogen. Avoid spilling the liquid on the accessory module housing.</td></tr>
<tr><td>4</td><td colspan="2">• Repeat step 3 until the detector dewar has been filled to maximum.

i Avoid overfilling as the liquid would then flow out of the filling port.</td></tr>
</table>

Table 5.8: Cooling procedure

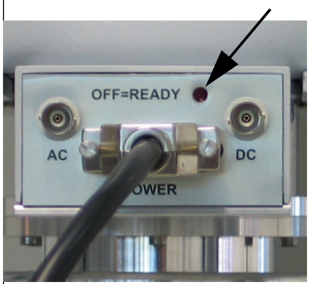
5	After filling has been completed, put on the protective cap of the detector dewar again. It may take up to 2 hours until the detector reaches its operational temperature. To ensure that the detector is ready, the LED OFF = READY, which is located on the Ge detector rear side, must be off. If the LED is red, the detector is still warm. 
6	Perform an OQ and PQ test. Details on these tests are described in the OPUS Reference Manual.

Table 5.8: Cooling procedure

5.8 Purging spectrometer

MultiRAM has one purge gas circuit to purge the complete optics compartment of the spectrometer using either dry air or low-pressure nitrogen. The circuit is fed by its own purge gas inlet which is located at the spectrometer rear side.

A high air humidity level inside the spectrometer impairs the measurement results. Therefore, purging the spectrometer is highly recommended to reduce the air humidity level. The purging procedure reduces the peak intensity of water vapor in the spectrum range.

When to purge?	If the peak intensity of water vapor is too high in the spectrum.
Purge gas:	• dry (dew point < -40°C), oil-free and dust-free air • nitrogen gas **⚠ WARNING** **Not using adequate gases for purging** Some spectrometer components become hot during operation. Risk of fire and/or explosion ➢ Never use flammable gases for purging.
Maximum pressure:	2 bar (29 psi)
Initial gas flow rate:	should not exceed 500 liters/hour
Sustained gas flow rate:	should not exceed 200 liters/hour

Table 5.9: Purging features

Procedure

Purging the spectrometer is described in chapter 3.9.2.

5.9 Checking reference lamp signal

i Checking the reference lamp signal should only be done before starting a measurement, which uses the reference lamp.

1. Position the sample in the sample compartment. For detailed information refer to appendix F.2.
2. Close the sample compartment.
3. Start the OPUS spectroscopy software, see the OPUS Reference Manual.
4. Set up the connection between spectrometer and PC.
   - ☞ On the *Measure* menu, select the *OPUS Optic Setup and Service* command.
   - ☞ Click the optical *Bench* tab.
   - ☞ Select the correct spectrometer type from the *Configuration* drop-down list.
5. On the *Manipulate* menu, select the *Black Body* command.

6. On the dialog that opens, enter 2300 K to specify the temperature of the black body. Click the *Calculate* button.
7. On the *Measure* menu, select the *Advanced Measurement* command.
8. Load the *WHTLGHT.XPM* experiment file:
   ☞ On the *Basic* tab, click the *Load* button. The experiment is stored in the *<OPUS/XPM* directory.
9. Click the *Check Signal* tab to observe the reference lamp signal.

5.9.1 Setting up experiment

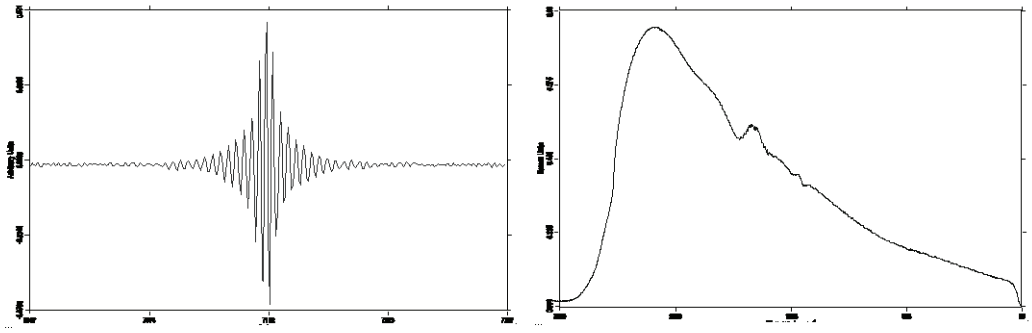
If there is no experiment file available, create one with the name *WHTLGHT.XPM* (white light).

1. On the *Measure* menu, select the *Advanced Measurement* command.
2. Define the following OPUS parameter settings on the *Advanced*, *Optics*, *Acquisition* and *FT* tab:

Tab	Parameter	Setting
Advanced	Result spectrum	Raman
Optic	Source	Reference lamp
	Measurement channel	Raman sample chamber
	Detector	Ge
	Mirror velocity	5 kHz
Acquisition	Acquisition mode	Double sided, forward backward
	Start frequency for file (Raman)	3,500
	End frequency for file (Raman)	50 (or 0)
FT	Phase correction mode	Power no peak search
	Apodisation function	Blackman-Harris 3 or 4 term
	Correlation	Raman

Table 5.10: Parameter settings for WHTLGHT.xpm experiment file

3. Compare the interferogram and spectrum with those shown in figure 5.2.



Interferogram Transformed spectrum

Figure 5.2: Interferogram signal of reference lamp and transformed spectrum

5.10 Performing measurements

5.10.1 General information

Before starting routine measurement, it is recommended to validate the spectrometer performance on a regular time interval. Perform a PQ[1] test using the OPUS Validation Program. The PQ test verifies the spectrometer operability in routine work. For detailed information on how to perform this test refer to the OPUS Reference Manual.

5.10.2 Measuring parameters

The measuring parameters are defined on the OPUS *Measure* menu. Select the *Advanced Measurement* command and define the parameters on the different tabs. By default, the *MultiRAM.xpm* experiment file is part of the OPUS software. This experiment file contains measuring parameters and settings which can be edited, if required.

1. PQ: Performance Qualification

5.10.2.1 Setting up standard measuring parameters

If the standard Raman measuring parameters are not available, create a Raman experiment file. Proceed as follows:

1. Start the OPUS spectroscopy software, see the OPUS Reference manual.
2. Set up the connection between spectrometer and PC.
   ☞ On the *Measure* menu, select the *OPUS Optic Setup and Service* command.
   ☞ Click the optical *Bench* tab.
   ☞ Select the correct spectrometer type from the *Configuration* drop-down list.
3. On the *Measure* menu, select the *Advanced Measurement* command.
4. Set up the following OPUS parameters on the different tabs:

Tab	Parameter	Setting
Basic	Laser	100 mW (initial value which can be changed in ALIGN mode by moving the slider)
Advanced	Result spectrum	Raman
Optic	Source	Reference lamp
	Measurement channel	Raman sample chamber
	Detector	Ge
	Mirror velocity	5 kHz
Acquisition	Acquisition mode	Double sided, forward backward
	Start frequency for file (Raman)	3,500
	End frequency for file (Raman)	50 (or 0)
FT	Phase correction mode	Power no peak search
	Apodisation function	Blackman-Harris 3 or 4 term
	Correlation	Raman

Table 5.11: Setting up standard measuring parameters

5. Save the standard parameters.
   ☞ On the *Advanced* tab, click the *Save* button. Define a name for the experiment file.

More details on the standard measuring parameters are described in appendix C.

5.10.3 Measuring procedure

1. **Start OPUS, the spectroscopy software.**
2. **Set up the connection between spectrometer and PC.**
   - ☞ On the *Measure* menu, select the *OPUS Optic Setup and Service* command. Click the *Optical Bench* tab and select the correct spectrometer type from the *Configuration* drop-down list. The OPUS status light at the lower right end of the OPUS interface has to be green before being able to start measurement.
3. **Enter measuring parameters.**
   - ☞ On the *Measure* menu, select the *Advanced Measurement* command and enter the parameters.
   - ☞ It is recommended to perform a measurement using the standard Raman parameter settings (see chapter 5.10.2.1 or appendix C).
4. **Load the measuring experiment.**

☞ On the *Basic* tab, click the *Load* button. The experiments are stored in the *<OPUS/xpm* directory. Load the *Raman.xmp* experiment.

5. **Position sample.**
6. **Check signal intensity.**

☞ Click the *Check Signal* tab. Possibly, optimize the signal intensity by changing the stage position. To change the stage position use the NUM pad of the PC keyboard (see also appendix F.3). The *Interferogram* option button must be activated to have the interferogram displayed. The interferogram indicates that a signal is detected. The amplitude value displayed above the interferogram shows the signal intensity currently detected.

☞ To check signal intensity compare the amplitude value displayed above the interferogram with the amplitude value indicated in the OQ test protocol. The supplied OQ (Operational Qualification) test protocol documents the result of a factory-performed OQ test. The test has been performed with the spectrometer being optimally adjusted. You find the OQ test protocol in the folder supplied with the spectrometer.

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i Especially after switching on the spectrometer, or after a power failure, it is advisable to check the intensity and position of the interferogram. Save the peak position (chapter 7.4).

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7. **Start sample measurement.**

☞ On the *Basic* tab, click the *Sample Raman Spectrum* button.

Detailed information on data acquisition and evaluation are described in the OPUS Reference Manual.

6 Maintenance

MultiRAM is a low-maintenance instrument, i.e. the operator can replace components with a limited service life (e.g. reference lamp). The following maintenance procedures are described in this chapter:

- Replacing reference lamp
- Replacing LED circuit board of status indicators
- Replacing defective internal detector
- Evacuating Ge detector
- Cleaning

6.1 General maintenance considerations

Perform only the maintenance procedures described in this chapter. Strictly observe the relevant safety precautions. Any failure to do so may cause property damage or personal injury. In this particular case Bruker does not assume any liability.

Maintenance procedures not described in this manual should only be performed by a Bruker service engineer.

The following precautions must be observed to ensure user and property safety:

- Disconnect power supply before performing any maintenance procedures.
- Be careful if the spectrometer covers are removed and the spectrometer is switched on to avoid contact with potentially harmful voltages.

6.1.1 Electrostatic discharge

Electronic components (e.g. semiconductor chips, printed circuit boards) are very susceptible to electrostatic discharges. Even discharge which may not be perceptible to the operator can damage electronic components. Therefore, it is important that the operator is discharged before touching any electronic component inside the spectrometer.

Electrostatic discharging can be accomplished by using a grounding wrist strap (not supplied) or touching a grounded object (e.g. radiator). The grounding wrist strap is the most effective and preferred grounding method.

6.1.2 Performing OQ[1] test by using OVP[2]

If you have exchanged a defective optical component, e.g. reference lamp we recommend running the OQ test using the OPUS validation software (OVP). This test checks whether the spectrometer achieves the specified performance parameter values.

Perform the OQ test only if you have replaced a defective component. Do not perform the OQ test if you have replaced a component for the purpose of spectral range extension.

More details on how to perform an OQ test are described in the OPUS Reference manual. If the OQ test fails, read about possible causes and solutions in the *Troubleshooting* chapter.

6.2 Replacing reference lamp

If the reference lamp, (part no: 82329) which is located in the sample compartment, is defective, you have to replace the bulb immediately. A defective reference lamp is indicated by the reference lamp status indicator (see chapter 4.1).

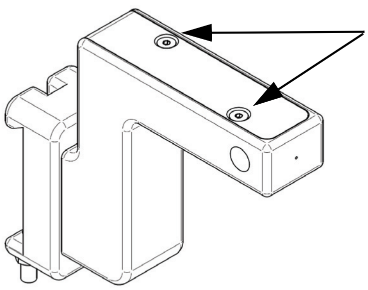
1	Carefully remove the reference lamp from its fixture in the sample compartment.	
2		Use a hex wrench to loosen the 2 M3 screws from the reference lamp housing.

Table 6.1: Replacing reference lamp

1. OQ test - Operational Qualification Test: This test is to be performed once a year, or after the replacement of any kind of defective optical component. During the OQ test, the following parameters are tested: resolution, sensitivity, energy distribution, wavenumber accuracy, photometric accuracy, scan time, peak position and peak amplitude.
2. OVP (OPUS Validation Program) is a program used to perform validation tests (e.g. OQ and PQ).

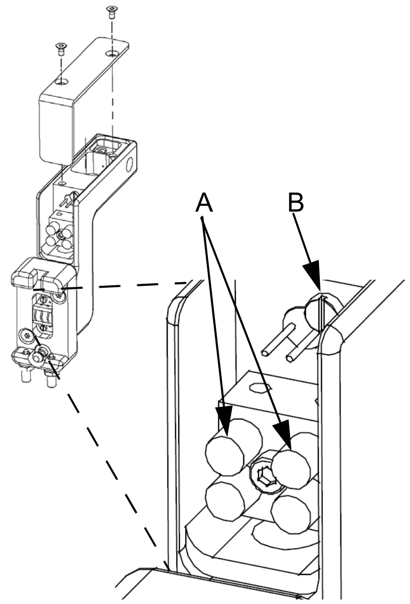
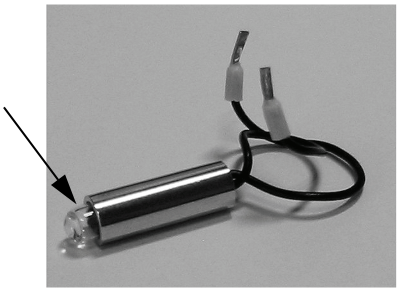
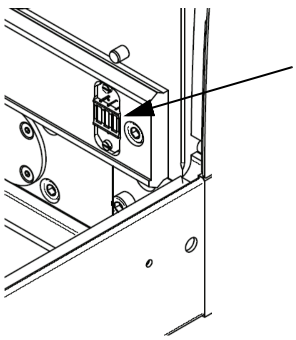
3		• Remove the cover plate from the reference lamp. • Loosen the top 2 screws (A) on the luster terminal, and the fixing screw (B) next to the lamp.
4	Remove the connectors from the luster terminal, and pull out the reference lamp from the fixture. ➢ Be careful, the lamp may still be hot.	
5		Pull out the defective bulb and replace it.
6	• Insert the reference lamp into the fixture, and fasten the fixing screw next to the lamp. • Put the connectors into the luster terminal and fasten the 2 top screws. • Attach the cover plate onto the reference lamp.	
7		Mount the reference lamp onto the corresponding connection fixture in the sample compartment.

Table 6.1: Replacing reference lamp

8	Check the reference lamp status indicator (chapter 4.1) on the front side of the Raman sample compartment. ➢ The LED must light green to ensure an error-free operation of the reference lamp.

Table 6.1: Replacing reference lamp

6.3 Replacing LED circuit board of status indicators

If one LED of the status indicators at the front side of the Raman sample compartment is defective, you have to replace the complete LED circuit board immediately.

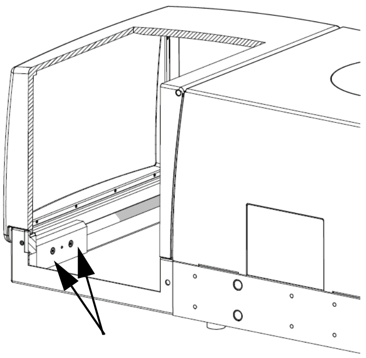
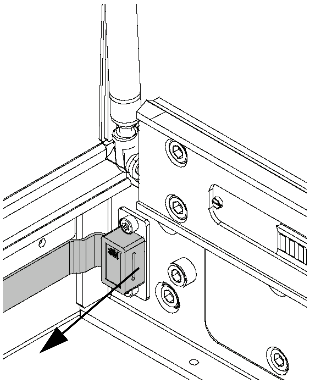
1		• Loosen the 2 screws of the LED circuit board housing, located in the sample compartment. • Remove the protective cover and pull out the circuit board.
2		At the other end of the LED circuit board there is a 9-pin connector. Remove this connector from the socket.
3	• Insert the new LED board and plug the 9-pin connector into the socket. • Check whether the LEDs work properly.	

Table 6.2: Replacing LED circuit board

6.4 Replacing defective internal detector

The internal detector position of the MultiRAM spectrometer either uses an InGaAs detector or an Si-avalanche diode. The replacing procedure is the same for both detector types.

The detector is fixed on a dovetail mounting, which facilitates the detector replacement. A re-alignment is not necessary.

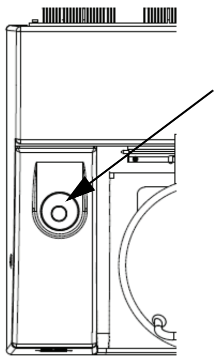
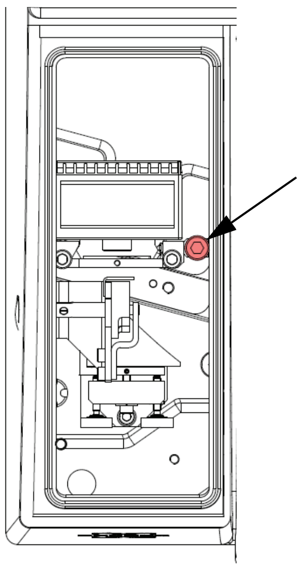
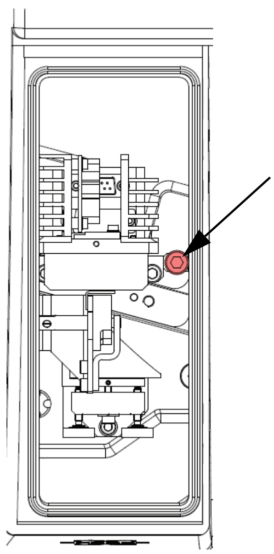
<table>
<tr><td>1</td><td></td><td>Removing cover from detector compartment.
☞ Remove protective cap from the top side of the cover (arrow in figure).
☞ Loosen the Allen screw (6 mm) located below the cap.
☞ Carefully lift off the cover from the detector compartment.</td></tr>
<tr><td rowspan="4">2</td><td colspan="2">Removing detector from detector compartment.
☞ Loosen the fixing screw (Allen screw: 6mm) located on the detector.</td></tr>
<tr><td>Position of fixing screw with InGaAas detector:</td><td>Position of fixing screw with Si-avalanche diode:</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">☞ Carefully remove the detector straight upwards from the dovetail mounting. Be careful not to damage any mirror.</td></tr>
</table>

Table 6.3: Replacing defective internal detector

3	Inserting new detector. ☞ Precisely insert the new detector into the dovetail mounting and push it right down. ☞ Fasten the fixing screw (Allen screw: 6 mm) again. ➢ *A beep indicates that the detector has been recognized by the spectrometer firmware.*
4	Mounting cover onto detector compartment. ☞ Place cover onto the detector compartment. ☞ Fasten the Allen screw again. ☞ Put the protective cap onto the top side of the detector compartment.
5	Check the signal intensity by using the OPUS software (chapter 5.10.3).

Table 6.3: Replacing defective internal detector

6.5 Evacuating Ge detector

The MultiRAM spectrometer can optionally be equipped with a Ge detector. To achieve the required operating temperature for the detector, the Ge detector is cooled by liquid nitrogen.

To ensure an as long as possible hold time[1] (cooling effect), the Ge detector is mounted inside a vacuum dewar. The actual hold time of a Ge detector strongly depends on the quality of the vacuum available in the detector dewar. This dewar must be evacuated if the actual hold time considerably decreases in relation to the nominal hold time.

i Evacuating the dewar is performed by Bruker service. This requires to de-install the Ge detector from the spectrometer, and to send it to Bruker Optik GmbH. Details on how to de-install the detector are described in chapter 5.6.

6.6 Cleaning

The outer spectrometer surface can be cleaned only by using a dry or damp cloth. Do not use detergents with organic solvents, acid or base!

1. The hold time indicates how long the cooling effect of the liquid nitrogen lasts.

7 Troubleshooting

This chapter describes possible spectrometer problems[1], their potential causes and recommended solutions. Spectrometer problems can be indicated by:

- status and diagnostics LEDs
- firmware diagnostics pages of hardware components (chapter 8.2)
- error messages in OPUS
- instrument test

If the solutions listed below do not solve the problem, contact Bruker service.

7.1 General information on fault diagnostics

A problem caused by a spectrometer component, that is either defective or not properly installed or not in operating condition, becomes apparent in several different ways. For example:

- You have started a measurement, but not any measurement result is displayed in OPUS.

➣ Reason: OPUS did not start any measurement at all.

- No signal detected in OPUS.
  ➣ Reason: Wrong OPUS parameters selected.
- You have started a validation test but OVP does not display a PQ or OQ test protocol.
  ➣ Reason: OVP did not start the validation test at all.

To find out the concrete cause of a spectrometer problem, it is advisable to narrow down the problem in a systematic way. We recommend the following fault diagnostics procedure:

- First, check the status LEDs on the spectrometer and the OPUS status light (chapter 7.2). If the OPUS status light is red, click the status light. The diagnostics view opens.
- Check whether one hardware component has the status WARNING or ERROR in OPUS. If yes, whether an error message is displayed for the respective component (chapter 7.2.1).
- Check the firmware diagnostics page (chapter 7.2.2) of the respective hardware component. Check whether there is any kind of reference to the possible cause of the problem.

1. Not all failures and causes can be outlined in this chapter. If the recommended solutions do not solve the problem, contact Bruker service.

7.1.1 Remote fault diagnostics

Remote fault diagnostics means that you send a complete spectrometer status report (also called Full Report) to Bruker via e-mail. This report enables a Bruker service technician to perform a first remote fault diagnostics.

The procedure for sending the report is different and depends on whether your spectrometer is connected to a network, network PC or a stand-alone PC.

7.1.1.1 If your spectrometer is connected to a network/network PC,...

With OPUS version 6 or higher, it is possible to save a complete report about the current spectrometer status. This report can be sent to Bruker service for remote fault diagnostics. Proceed as follows:

1. Click the OPUS status light ().
   ➣ The *Instrument Status* dialog opens.
2. To send the report click the *Send Report* button.
   ➣ The report is sent by e-mail to *opusreports@brukeroptics.de.*

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i This function requires an e-mail program installed on your PC and an e-mail account to be set up. In addition, your spectrometer needs to be connected to a network PC.

7.1.1.2 If your spectrometer is connected to a stand-alone PC,...

1. Generate a full report manually and save it (chapter 8.3.1).
2. Transfer the full report file to a network PC. Make sure that an e-mail program is installed on this network PC, and an e-mail account set up.
3. Send the full report to *opusreports@brukeroptics.de* as an attached file.

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i To be able to use this feature an e-mail program must be installed on the network PC, and an e-mail account set up.

7.2 Status light in the OPUS spectroscopy software

The status light in the OPUS spectroscopy software is located on the lower right end of the interface. It indicates the status based on the currently active channel or measurement experiment loaded.

The OPUS status light can indicate different types of operating states.

LED	Definition
	Gray: no spectrometer connected
	Green: spectrometer is connected and works properly
	Yellow: warning (e.g. service life of a spectrometer component comes to an end, instrument test has expired etc.) i Measuring is still possible.
	Red: error (e.g. spectrometer malfunction, defective spectrometer component, instrument test failed etc.) i Measuring is not possible.

Table 7.1: OPUS status light

7.2.1 *Instrument Status* dialog in OPUS

The *Instrument Status* dialog in OPUS shows the status of each hardware component, and the status of the instrument test for the measurement channel currently used.

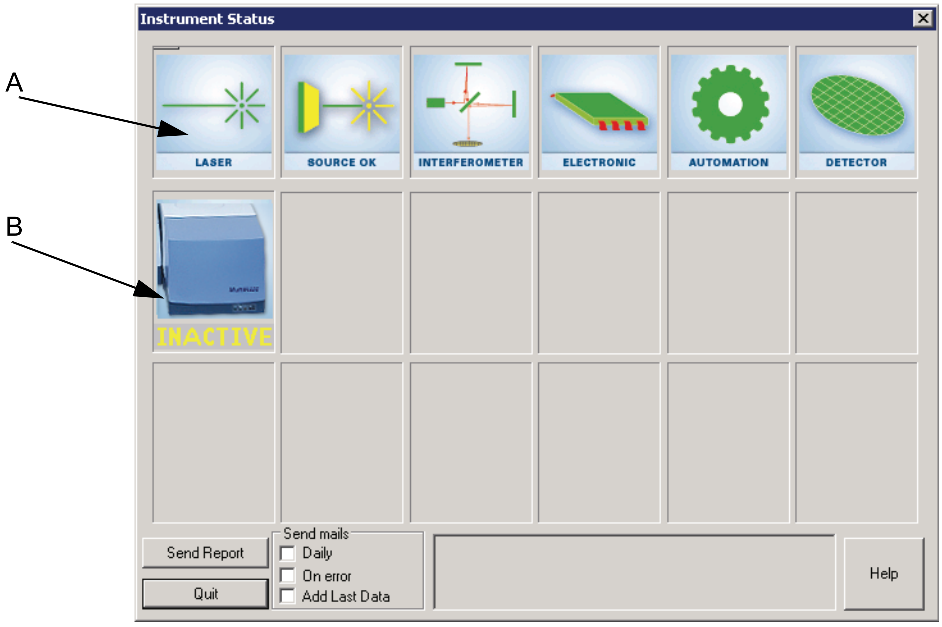


Figure 7.1: OPUS *Instrument Status* dialog

A) Status of hardware components, e.g. source, laser etc is displayed. The status can be as follows:

Status	Definition
	**OK** (green): component is ok
	**Warning** (yellow): the exact meaning depends on the specific component; in case of the source a warning means: • source lifetime nearly reached (measuring is still possible) • source warms up (measuring not possible)

Table 7.2: Hardware status

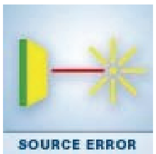
Status	Definition
	**Error** (red): Component is defective (measuring not possible)

Table 7.2: Hardware status

B) The second row of icons refers to the current measurement channel used, and indicates the result of the last instrument test performed. The results can be as follows:

Status	Definition
	**INACTIVE** (yellow): the single tests of the particular test category are disabled
	**PASSED** (green): instrument test configured or passed, test is still valid
	**EXPIRED** (light blue): instrument test validity period has expired
	**FAILED** (red): last instrument test has failed

Table 7.3: Status of measuring channel

7.2.2 Spectrometer problems indicated by diagnostics pages of hardware components

To perform fault diagnostics for a particular hardware component proceed as follows:

1. On the *Instrument Status* dialog, click the icon which indicates an error or warning.
   ➢ The *Instrument Status Message* dialog opens.
2. Click the *Service Info* button.
   ➢ The firmware diagnostics page of the respective spectrometer hardware component opens. This page contains all relevant information about the current operating state of the respective hardware component.

i You can send the diagnostics pages of all hardware spectrometer components as full report to Bruker service for remote fault diagnostics. Use the following e-mail address: *info@brukeroptics.com*

7.3 Spectrometer problem indicated by an error message in OPUS

Error messages which refer to the spectrometer can be displayed in OPUS as follows:

- in the *Instrument Status* dialog
- by means of a yellow message bubble at the lower right end of the OPUS interface
- in a normal message window

i In case of a spectrometer problem indicated by an error message, the OPUS status light is yellow or red.

Error message in OPUS	Possible cause	Troubleshooting
Humidity out of range.	Air humidity inside the spectrometer is too high	Contact Bruker service.
Temperature out of range.	Temperature inside the spectrometer is too high. Cause: Ambient temperature is too high.	Operate the spectrometer only in the ambient temperature range specified (5 - 35°C) by the manufacturer.

Table 7.4: Error messages in OPUS

Error message in OPUS	Possible cause	Troubleshooting
An instrument calibration is required.	**i** This message appears every six months. This kind of setting is factory-set. The purpose of a regular recalibration is to ensure that the measurements are performed with a correct laser wavenumber.	• Click the *Calibrate* button. • Wait until the calibration has been finished.
Laser is off or no laser signal.	Defective laser	Contact Bruker service.
Scanner initialization mode.	This error message appears when you try to start a measurement while the spectrometer is still initializing. **i** Further messages may be displayed. As they do not represent a spectrometer problem you can ignore them.	Wait until initialization has been finished.
If an error message appears which is not listed above,.......		...contact Bruker service.

Table 7.4: Error messages in OPUS

7.4 No interferogram in check signal mode

In this case, it is assumed that no interferogram will be displayed on the *Check Signal* tab in the OPUS *Measure* dialog (see OPUS Reference Manual).

Assuming that the spectrometer can be accessed and that there is an optical connection between the interferometer outlet and detector inlet, the problem can be caused by:

Possible cause	**Troubleshooting**
Wrong measurement parameters	Use the measurement parameters as described in appendix C.
Detector is not cooled down at operating temperature. Error message: *Detector not ready.*	Cool detector. ☞ In case of a liquid-nitrogen cooled detector, fill liquid nitrogen into the dewar (chapter 5.7). ☞ In case of a thermoelectrically cooled detector, contact Bruker service.
Detector not or incorrectly installed. Error message: *The Device not connected. No analog board selected.*	• In case of internal detector: ☞ contact Bruker service • In case of external detector: ☞ examine the cable connection at the detector as well as on the spectrometer rear side
No or wrong detector type selected	Select correct detector type in the OPUS software. ☞ On the *Measure* menu, select the *Advanced Measurement* command. ☞ Click the *Optic* tab and select the correct detector type from the *Detector* drop-down list.
Wrong peak position saved	Determine and save the correct peak position. ☞ On the OPUS *Measure* menu, select the *Advanced Measurement* command. ☞ On the *Check Signal* tab, click the *Save Peak Position* button.
Spectrometer error: the red ERR LED is on, which is located on the rear spectrometer side.	Possible cause: Strong mechanical shocks have caused a temporary or permanent optics misalignment or the HeNe laser is defective. Contact Bruker service.

Table 7.5: No interferogram in check signal mode

Possible cause	Troubleshooting
Defective power supply unit	• Check the voltage status LEDs on the spectrometer rear side. • If all LEDs lights are off, the power supply unit probably needs to be replaced. Contact Bruker service.
Temporary or permanent optics misalignment caused by strong vibrations	• Place the spectrometer on a vibration-free location. • If the problem still persists, contact Bruker service.

Table 7.5: No interferogram in check signal mode

7.5 Spectrometer problem indicated by diagnostics LEDs

On the spectrometer rear side, the voltage status LEDs are located on the power supply panel (chapter 10.3) and the ERR and SR diagnostics LEDs are located on the electronics panel (chapter 10.2).

7.5.1 Voltage status LEDs

LED	Definition
+5V, +12V, -12V	• Green = spectrometer connected to power supply • Black = power supply to spectrometer interrupted

Table 7.6: Voltage status LEDs

7.5.1.1 All voltage status LEDs off

The voltage LEDs are labeled +5V, +12V and -12V. All three LEDs, which are located on the rear spectrometer side, must be green during normal operation. If all voltage LEDs are off, this may be due to the following reasons:

Possible cause	Troubleshooting
Spectrometer switched off	Switch on spectrometer.

Table 7.7: All voltage status LEDs off

Possible cause	Troubleshooting
Power cord not connected	Connect power to spectrometer and main power supply.
Voltage not available	Check whether proper voltage is supplied at the main power supply.
Short circuit in the power supply	• Disconnect power supply unit immediately. • If any additional external circuitry is connected to the CAN bus or MPE port, disconnect them and switch on spectrometer again. If the problem is solved, the external part caused a short-circuit of the power supply. If not, it is an internal problem of the spectrometer electronics. Contact Bruker service.
Defective power supply unit	Contact Bruker service.

Table 7.7: All voltage status LEDs off

7.5.1.2 One voltage status LED off

The voltage LEDs are labeled +5V, +12V and -12V. All three LEDs, which are located on the rear spectrometer side, must be green during normal operation. If one voltage LED is off, this may be due to the following reasons:

Possible cause	Troubleshooting
An external device shortens the power supply unit	• Disconnect all external devices from the CAN bus or MPE port. • Switch on the spectrometer again.
Short circuit in the spectrometer	Switch off the spectrometer, wait about 30 seconds and switch it on again. ➢ If the initialization phase has finished, the power supply LED becomes green.
Defective LED	In this case there is no spectrometer malfunction and the spectrometer operates properly. • The defective LED has to be replaced. • Contact Bruker service.

Table 7.8: One voltage status LED off

7.5.2 ERR and SR LEDs

LED	Definition
ERR	• Slightly red = scanner in operation • Permanently red = severe scanner problem ➢ No data acquisition possible
SR	Red = spectrometer is busy and performs action ➢ No communication via Ethernet possible

Table 7.9: ERR and SR LEDs

7.5.2.1 Red ERR LED

In normal operation mode, the ERR LED flashes slightly red and indicates the scanner movement. If the LED is permanently red, there must be an interferometer problem, i.e. components/conditions that are involved in the scanner functioning (laser, beamsplitter etc.) can cause a red ERR LED. As long as this LED is permanently red no data acquisition is possible.

Possible cause	Troubleshooting
• Laser beam blocked • Laser unit not installed correctly • Defective laser	Contact Bruker service.
Strong mechanical shocks have caused a permanent optics misalignment	Contact Bruker service.

Table 7.10: Diagnostics LEDs - Red ERR LED

7.5.2.2 SR LED permanently on

The SR LED indicates that the instrument is busy and not available for communication.

Possible cause	Troubleshooting
Spectrometer still in initialization phase	Wait about 1 minute until the initialization procedure is finished.
Spectrometer control hangs	• Reset the spectrometer. Press the RES button on the spectrometer rear side. • Wait for the initialization procedure to terminate. • If the LED is still on, click the OPUS status light on the lower right end of the OPUS interface. • If the problem still persists, contact Bruker service.

Table 7.11: Diagnostics LEDs - SR LED is permanently on

7.6 No data transfer between spectrometer and PC

In this case troubleshooting depends on the connection topology. The default connection (stand-alone configuration) is installed via a cross-over cable between the PC and the spectrometer 100Base-T port (labelled ETH on the electronics panel, chapter 10.2).

Alternatively, the spectrometer can be directly connected to an Ethernet network using the 100Base-T port.

i The direction of data transfer is indicated by the RX and TX LEDs located on the electronics panel. The TX LED is active when the spectrometer sends data, and the RX LED is active when the spectrometer receives data.

7.6.1 RX LED permanently off

If the green RX LED is permanently off, there may be a problem with regard to the physical connection between the spectrometer and the PC or network.

Possible cause	Troubleshooting
Wrong cable type used	• Use a CAT5 cross-over 100Base-T cable to directly connect the spectrometer to the PC. • Use a regular CAT5 100Base-T cable to link the spectrometer to an existing network. • Ask your local network administrator.
Defective cable or unstable connection	• Check the RJ-45 connection to the ETH port, and the connection at the other end of the cable. • Replace the cable, if necessary
Spectrometer does not start up	Check main power supply. i The voltage status LEDs +5V, +12V and -12V, which are located on the spectrometer rear side, must be green when the spectrometer is switched on.

Table 7.12: RX LED permanently off

7.6.2 Green RX LED on while trying to establish a connection, but the yellow TX LED off

This indicates that there is no logical connection available, between the spectrometer and network or PC.

Possible cause	Troubleshooting
Wrong IP address assigned to the spectrometer	Assign the correct IP address to the spectrometer. ➢ The correct IP address sticks on a label, which is located on the spectrometer rear side. For detailed information refer to chapter 9.2.
TCP/IP settings mismatch between spectrometer and PC/network	See chapter 9.1.

Table 7.13: Green RX LED on, yellow TX LED off when connection is established

If you do not succeed in solving the communication problem between spectrometer and PC, consult your network administrator. To provide the network administrator with the relevant information, proceed as follows:

1. On the Window desktop, click the *Start* button.
2. Select *Run*.
3. Enter *cmd* and click *OK*.
4. Enter *route print* and press the ENTER key.
5. Enter *ipconfig/all* and press the ENTER key again.
6. Take a screenshot of the dialog and submit it to your network administrator.

7.7 Diagnostics via instrument test

The instrument test checks whether the spectrometer achieves the performance specified. This test is called OVP test which is a collective term for all tests (e.g. OQ[1] or PQ[2] test) that can be performed by means of the OPUS Validation Program (OVP).

i For detailed information about OVP refer to the OVP for Raman manual.

If the instrument test has failed, an OVP Test Protocol (PDF file) is automatically displayed on the screen. The PDF file with the test protocol is always saved in the <*OPUS \Validation\Reports* directory.

1. OQ: Operational Qualification test, checks the instrument performance after installation and maintenance
2. PQ: Performance Qualification test, checks the instrument performance and proper function for daily work

If the instrument test has failed, read the test protocol and try to repeat the instrument test. Proceed as follows:

1. On the *Instrument Status* dialog, click the icon for the current test channel.
   ➢ The OVP Test dialog opens.
2. Repeat the test(s) failed.
   ➢ For details refer to the OPUS Reference manual.

7.7.1 Specifications of instrument test failed

7.7.1.1 General

Possible cause	Troubleshooting
Wrong OVP configuration	Check the configuration. If no errors can be detected, contact Bruker service.
Unknown loss of spectrometer performance	Contact Bruker service.
Wrong measurement parameters used	Modify measurement parameters according to the ones indicated in the OQ test.

Table 7.14: General causes and troubleshooting

7.7.1.2 Raman related problems

Possible cause	Troubleshooting
Highly absorbing sample	Reduce laser performance or defocus laser (chapter F.5).
Fluorescence	Use different sample glass tubes and different wavelengths.
Heat peak	Reduce laser performance and use a different sample spot. Alternatively, use thermal filters.

Table 7.15: Raman related problems

8 Web Interface

8.1 Access rights

Especially, if the spectrometer is connected to a network access conflicts may occur. In OPUS, only one user can access the spectrometer at a given time. Once a user is connected to the spectrometer, access trials by any other PC are blocked. In this case, the OPUS interface of this PC, which tries to get access, shows a gray ( ) status light. An additional message is displayed on the *Optic Setup and Service* dialog when you click the *Optical Bench* tab:

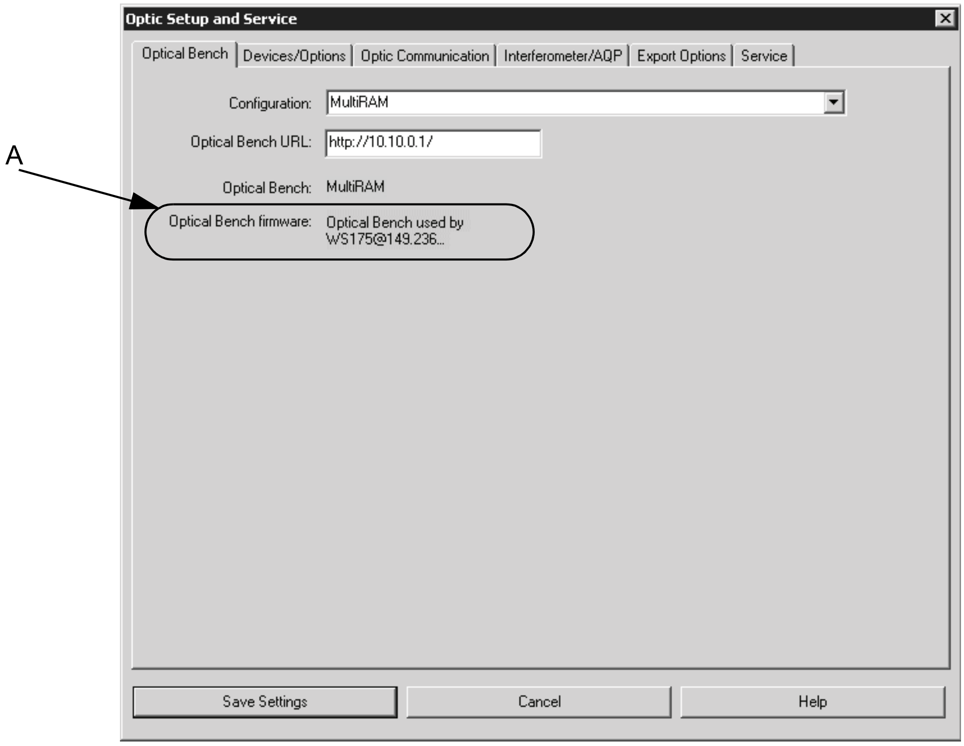


Figure 8.1: OPUS - Optic Setup and Service, Optical Bench tab

The IP address of the PC which has currently access to the optics is indicated (A).

On a Web browser, however, more than one user can simultaneously access a particular spectrometer - on the same or on a different PC -, even in parallel to an access connection already established via OPUS. All these types of connections are served on a first-come-first-serve basis.

Intentionally, there is no locking mechanism between the Web interface and OPUS. Thus, it is recommended not to access the spectrometer by a Web browser in parallel to a connection via OPUS, during normal measurements. Such parallel access is intended only for service and maintenance purposes. You may easily destroy your measurement or completely lock OPUS by a single click on a button (e.g. *Reset instrument*).

To ensure network reliability use the stand-alone configuration (see chapter 9) or contact your network administrator to restrict the access rights within the network.

8.2 General information on the firmware pages of the spectrometer

Due to the integrated EWS15 board (Embedded Webserver Board), the spectrometer operates like a Web server, i.e. the spectrometer can be accessed using a Web browser (e.g. Microsoft Internet Explorer, Netscape Internet Browser). This kind of spectrometer accessing requires a physical connection between the spectrometer and PC as well as knowledge about the spectrometer IP address.

If you open the Web browser and enter the spectrometer IP address (default IP address: 10.10.0.1) into the address field of the Web browser (A in figure 8.2), the firmware start page of the particular spectrometer is displayed. If you do not know the IP address, see the white label at the electronics panel.

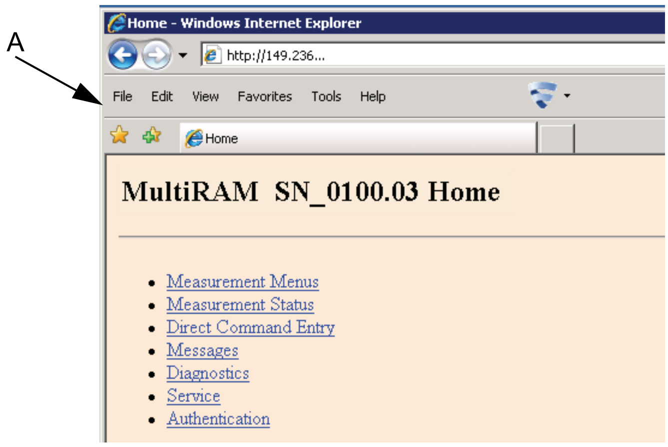


Figure 8.2: Firmware start page - MultiRAM

8.2.1 User authentication

To ensure network reliability the spectrometer firmware provides a user authentication via Web browser for sensitive instrument configuration pages and blocks unauthorized modification of the instrument configuration. The protected configuration pages are:

- *Measurement Menus*
- *Direct Command Entry*
- *Service/List of result data files*
- *Service/Special commands A*
- *Service/Special commands B*
- *Service/Reset Instrument*
- and all *Service/Edit hardware configuration* pages, except for the *Backup Flange Eeprom* data to *Flashdisk* and *Backup NVRam to Flashdisk* pages

The user authentication has no influence on the communication connection established to the spectrometer via OPUS.

i Only one user account (combination of user name and password) is supported. A particular user can be logged on from several workstations at the same time.

8.2.1.1 Activating user authentication

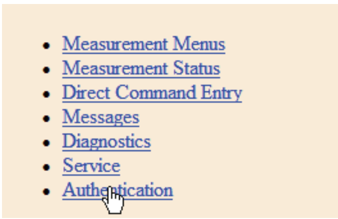
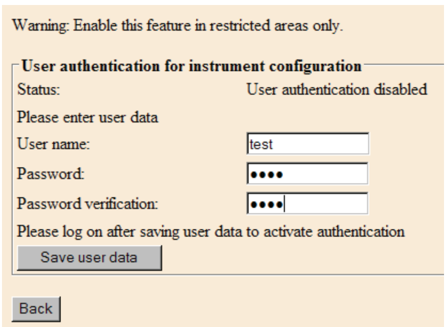
1		• Open Web browser. • Enter spectrometer IP address into the address entry field. • On configuration page, click *Authentication*.
2		• Enter user name and password. • Confirm password.

Table 8.1: Activating user authentication

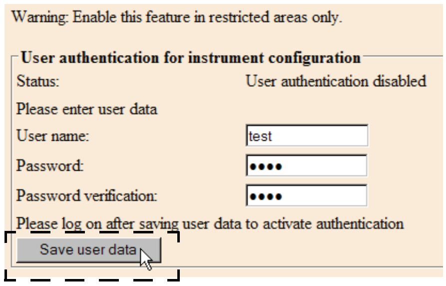
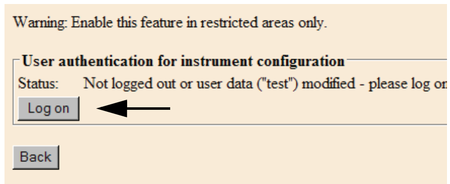
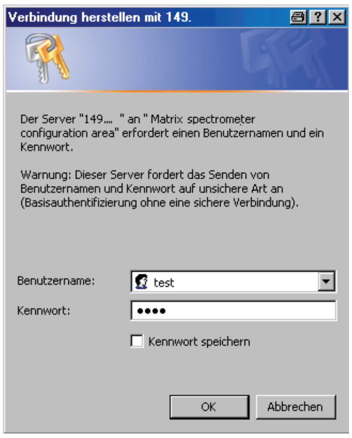
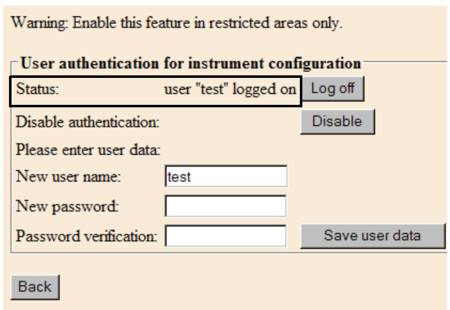
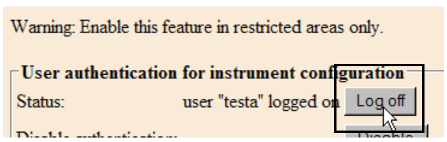
3		Click *Save user data* button.
4		Click *Log on* button.
5		• Enter user name and password. • Click *OK* to confirm.
6		The status line now reads: *user "xxx" logged on*. ℹ To have the user authentication become effective you have to log off.
7		Click the *Log off* button.

Table 8.1: Activating user authentication

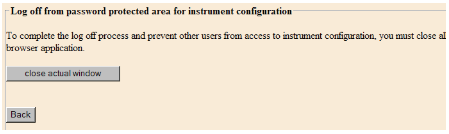
8		• Click the *close actual window* button. • Click *Yes* to confirm the action.
9	• Open Web browser. • Enter spectrometer IP address again. **i** Now, if you open the browser again, the instrument configuration pages which are protected cannot be accessed any more. As soon as you try to open one of these pages a dialog pops up, asking for the user name and password.	

Table 8.1: Activating user authentication

8.2.1.2 Deactivating user authentication

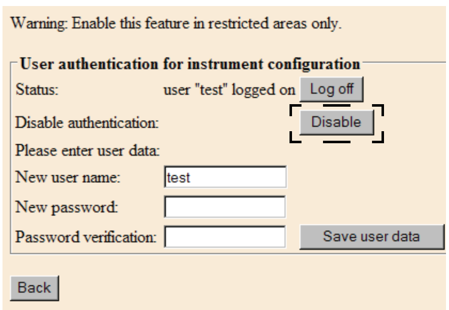
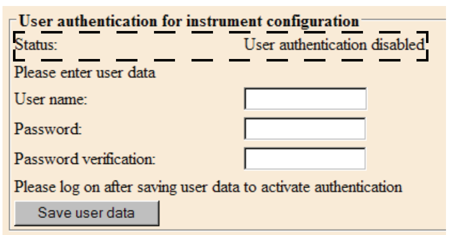
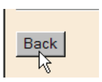
1		• Open Web browser. • Enter spectrometer IP address into the address entry field. • On configuration page, click *Authentication*.
2		Click the *Disable* button.
3		The status line now reads: *User authentication disabled*.
4		Click the *Back* button to return to the configuration page again.

Table 8.2: Deactivating user authentication

8.3 Full report

The full report is a useful fault diagnostics tool. This report provides all the necessary information about the instrument configuration and complete spectrometer status.

This report also includes error messages, internal and external data transfer as well as values of all relevant parameters. The full report is an important and - especially if a problem or failure has occurred - indispensable tool for fault diagnostics by service engineers.

8.3.1 Generating full report

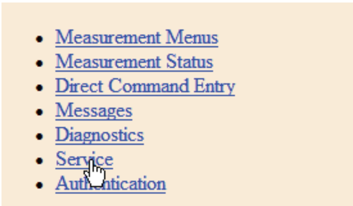
1		• Open Web browser. • Enter spectrometer IP address into the address entry field. • On configuration page, click *Service*.
2		Click the *Full Report* option. The current full report is displayed.
3	• On the *File* menu of the Web browser, click the *Save as* command. • Use the file extension **.htm*. • Send original htm file to Bruker. Do not generate any screenshots or text files.	

Table 8.3: Generating full report

i Save the full report immediately after a problem or failure has occurred. Otherwise, important information will be overwritten by newer entries.

9 Data Communication

To connect the spectrometer to a computer, on which the OPUS software runs, you have to perform the following steps:

1. Selecting a connection topology
2. Defining the corresponding network address
3. Assigning the network address
4. Checking the connection

What types of configurations are possible?

- Connecting spectrometer to a stand-alone computer (standard configuration)
- Connecting both spectrometer and computer to a network
- Connecting spectrometer to a network computer

Data cable type

The data cable type depends on the configuration used.

Data cable type	Configuration	Included in delivery content?
Cross-over cable	• Spectrometer to stand-alone computer • Spectrometer to network computer	Yes
Straight-through cable[a]	• Spectrometer to network • Spectrometer to network computer	No

Tabelle 9.1: What data cable type for what configuration type

a. A straight-through data cable, category 5, with RJ45 plugs for the Ethernet standard 10/100Base-T is required. The data cable length should not exceed 100m (without repeater).

The figure below illustrates the RJ-45 Ethernet cable wiring for a straight-through and cross-over cable.

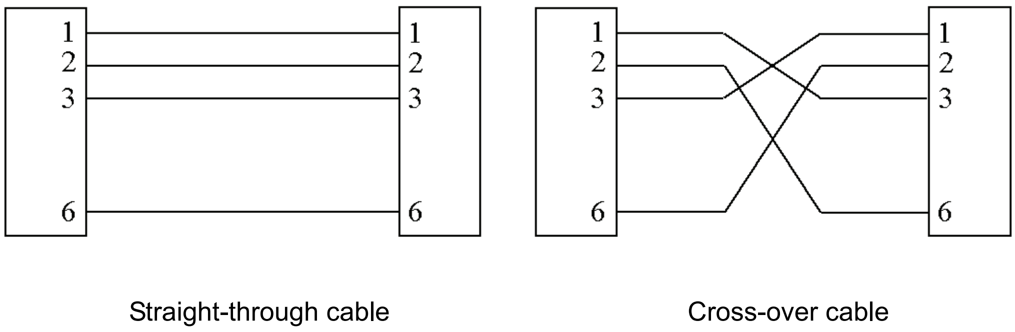


Figure 9.1: RJ-45 Ethernet cable wiring

9.1 Configuration types

9.1.1 Connecting spectrometer to a stand-alone PC (standard)

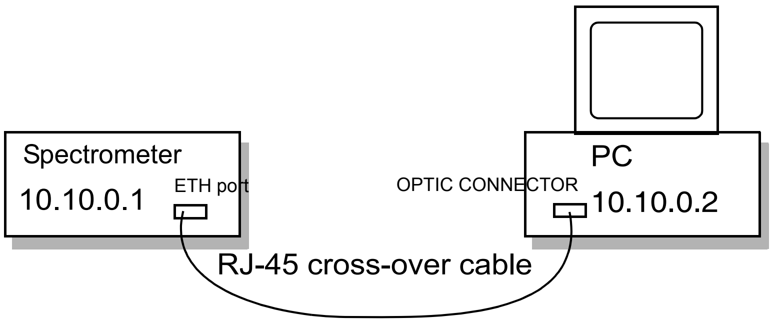


Figure 9.2: Connecting spectrometer to stand-alone PC

1. Connect one end of the supplied cross-over data cable to the ETH port on the spectrometer rear side.
2. Connect the other end of the supplied cross-over data cable to the OPTIC CONNECTOR on the PC rear side.

i If you have NOT purchased the PC with Bruker, you have to assign the IP address 10.10.0.2 to the PC to which you want to connect the spectrometer.

3. Check the communication connection between spectrometer and PC.

Advantages of this configuration type

- Full bandwidth available for data transfer between spectrometer and PC
- No access problems with other PCs which also try to access the spectrometer
- No data transfer problems caused by varying data transfer rates

Disadvantages of this configuration type

- No remote access to spectrometer from other PCs on which the OPUS software is installed
- Stand-alone PC cannot use network resources
- Local printer required to print measurement results

9.1.2 Connecting spectrometer and PC to a network

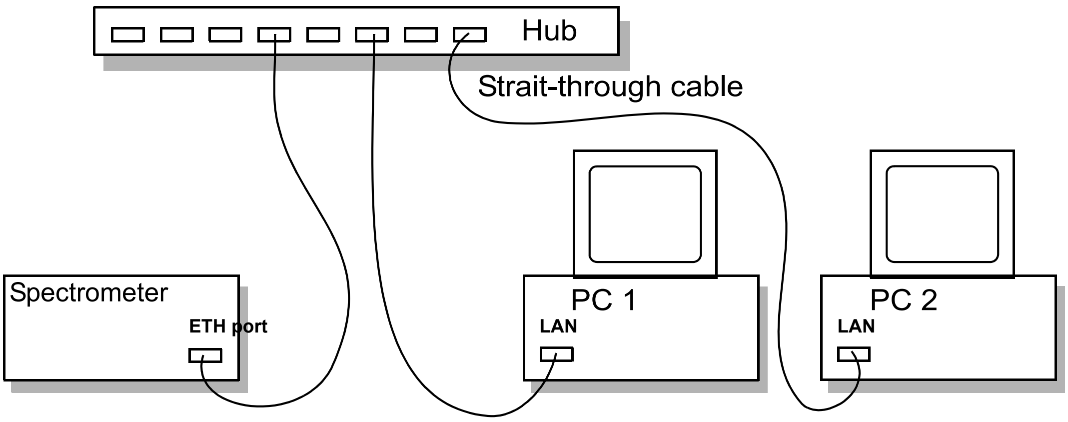


Figure 9.3: Connecting spectrometer and PC to a network

1. Connect one straight-through cable, category 5 with RJ45 plugs for the Ethernet standard 10/100Base-T, to the spectrometer ETH port and to the network hub.

i The number of data cables required depends on the number of PCs which are to be connected to the network.

2. Connect a second straight-through cable to the LAN connector on the rear PC side, and to the network hub.
3. Assign IP address to the spectrometer. This IP address needs to be defined by the network administrator.
4. Assign IP address to the PC (LAN network interface card). This IP address needs to be defined by the network administrator.
5. Check communication connection between spectrometer and PC.

Advantages of this configuration type

- Remote access to spectrometer via internet or intranet possible
- PC can access all network resources, provided you have the necessary access rights

Disadvantages of this configuration type

- Straight-through data cables are required which are not included in the delivery scope
- A small range of the bandwidth is available for the data transfer between spectrometer and PC. The measurement time may increase due to data transfer delays. If the average transfer rate is less than the required transfer rate, the buffer in the optics controller eventually overflows and the measurement is unusable.
- Possible access problems caused by other PCs which also try to access the spectrometer.

9.1.3 Connecting spectrometer to network PC

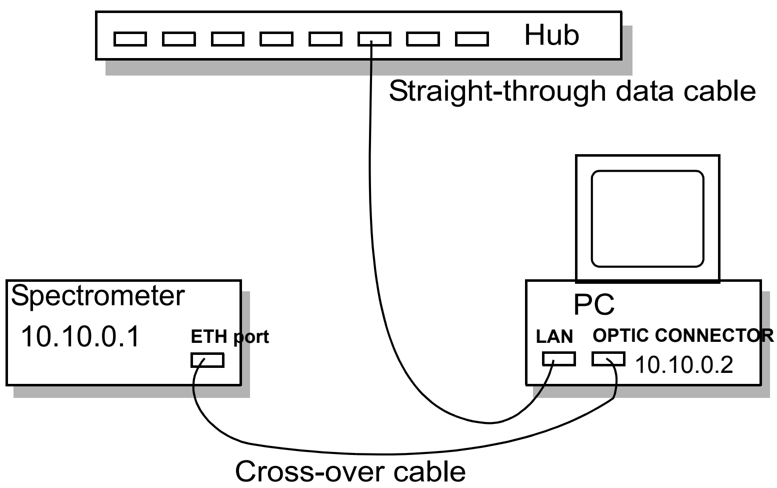


Figure 9.4: Connecting spectrometer to network PC

1. Connect one end of the supplied crossover data cable to the ETH port on the spectrometer rear side, and the other to the OPTIC CONNECTOR on the PC rear side.
2. Connect a straight-through cable, category 5 with RJ45 plugs for the Ethernet standard 10/100Base-T, to the LAN connector on the PC rear side and to a network hub.
3. Assign IP address to the PC (LAN network interface card). This IP address needs to be defined by the network administrator.

i If you have NOT purchased the PC with Bruker, you have to assign the IP address 10.10.0.2 to the network interface card of the PC to which you want to connect the spectrometer.

4. Check communication connection between spectrometer and PC.

Advantages of this configuration type

- Full bandwidth is available for data transfer between spectrometer and PC
- Remote access to spectrometer via internet or intranet is possible, provided you have the necessary access rights
- The PC can access all network resources, provided the necessary access rights are available
- Different data transfer rates for data exchange between spectrometer (100Base-T) and the network connection (no restrictions) are possible

Disadvantages of this configuration type

- Straight-through data cable is required which is not included in the delivery scope
- A decrease in computing speed, due to the integration of the PC in a network, may affect time-critical measurements

9.2 Network addresses

Depending on the configuration type selected, use the IP addresses described in the following.

9.2.1 Standard configuration: connecting spectrometer to a stand-alone PC

The spectrometer and the PC delivered by Bruker are configured for the stand-alone operation, i.e. the correct network addresses have already been assigned to the spectrometer and PC.

If you have not purchased the PC with Bruker, you have to assign the following network addresses to the PC.

	Spectrometer	PC	Note
IP address	10.10.0.1	10.10.0.2	--
Subnet mask	255.255.255.0	255.255.255.252	--
Gateway	0.0.0.0	0.0.0.0	do not define when using Windows XP

Table 9.2: Network addresses for standard configuration

9.2.2 Optional configuration: spectrometer and PC connected to a network

- Spectrometer and PC must have a unique IP address.
- IP address depends on the local intranet and must be assigned by the network administrator.
- If the spectrometer is to be accessed via internet, you have to specify a gateway address. The gateway links the intranet domain to other domains (e. g. internet domains).
- If no gateway is defined, set the gateway address to 0.0.0.0.
- Do not specify a gateway when using Windows XP as operating system.

9.2.3 Optional configuration: spectrometer connected to network PC

The configuration spectrometer connected to network PC requires 2 network interface cards and 3 sets of addresses:

- set of address for the spectrometer
- set of address for the OPTIC CONNECTOR network card (communication PC/ spectrometer)
- set of address LAN network card (communication PC/network)

	Spectrometer	**OPTIC CONNEC-TOR network card**	**LAN network card**
IP address	10.10.0.1	10.10.0.2	assigned by network administrator
Subnet mask	255.255.255.0	255.255.255.252	assigned by network administrator
Gateway	0.0.0.0 do not define when using Windows XP	0.0.0.0 do not define when using Windows XP	assigned by network administrator

Table 9.3: Network addresses when connecting spectrometer to network PC

9.3 Assigning network address

When delivered, the spectrometer uses the standard IP address 10.10.0.1. Assigning a different IP address only becomes necessary if the spectrometer is to be directly connected to a network. This IP address has to be assigned by the network administrator.

The FCONF (Firmware Configuration) program is used to assign a new IP address to the spectrometer. This program is part of the OPUS software. The single steps required for assigning IP addresses are described in the following:

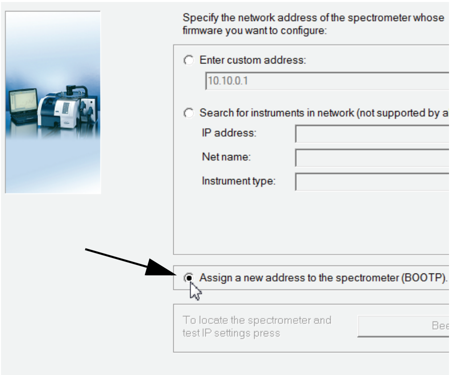
1	Start FCONF program. ☞ Double click the *fconf.exe* file in the OPUS base path.	
2		• Activate the *Assign a new address to the* spectrometer button. • Click the *Next* button.

Table 9.4: Assigning network address

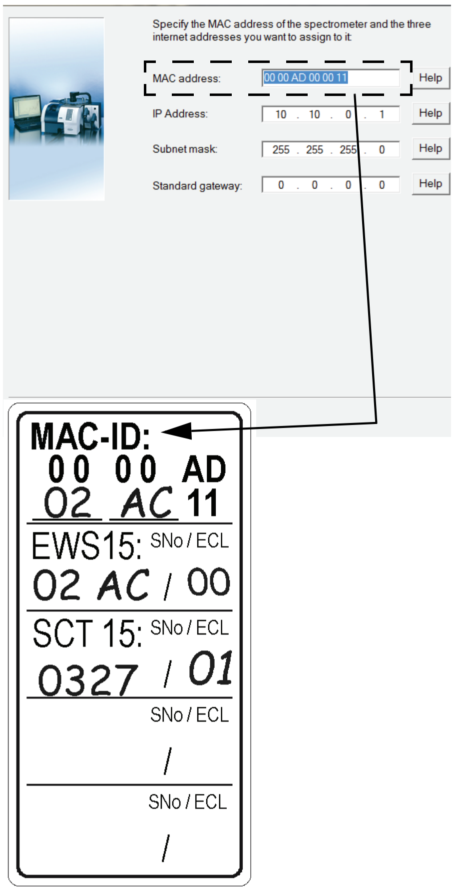
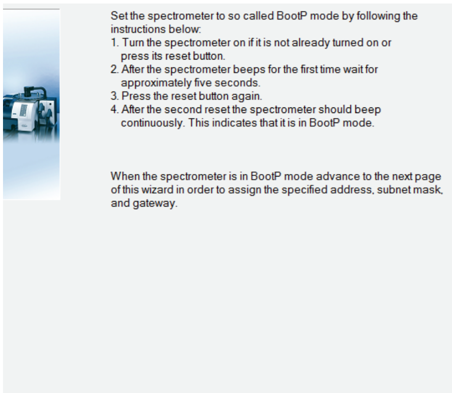
3		• Enter MAC (Media Access Control Address), IP and Gateway address. ☞ The *Help* buttons provide additional information on how to fill in the different lines. ➣ The MAC address is the unique hardware name of the network interface adapter installed inside the spectrometer. You find this address on the label on the rear spectrometer side. In the example on the left, the MAC address is 00 00 AD 02 AC 11. ➣ Always keep the MAC address on the label up to date and legible. A wrong MAC address will lead to confusion. ➣ The entries for the remaining three entry fields of the dialog depend on the network connection type selected betwen PC and spectrometer. The figure shows the standard addresses for the direct connection between spectrometer and PC. • Click the *Next* button.
4		You are prompted by the programm to set the spectrometer into BootP-mode. ☞ Follow the on-screen instructions. • Click the *Next* button.

Table 9.4: Assigning network address

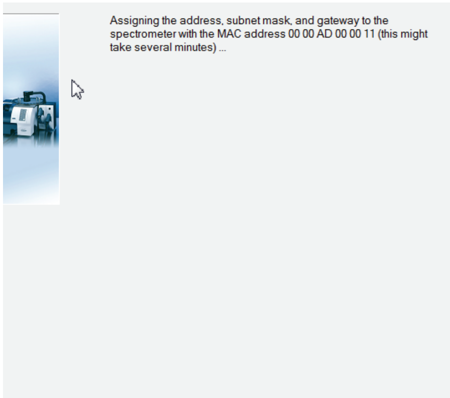
5		➢ The assigning procedure starts immediately and may take several minutes. ➢ If the action has been finished successfully, a message confirms the action and the spectrometer automatically reboots. ➢ The spectrometer starts up with the newly-assigned IP settings and can be accessed by the PC. • Replace the removable label on the spectrometer rear side by the new IP-address.

Table 9.4: Assigning network address

9.4 Communication between spectrometer and PC

1. Switch on spectrometer.
2. Wait about 1 minute to allow the spectrometer to boot. A dark SR LED indicates that the boot process is completed.
3. Start the internet browser.

   ➢ Make sure that the internet browser is not off-line. In case of the Microsoft Internet Explorer the off-line mode is activated if the *Offline Mode* command on the *File* menu of the browser is checked.

   ➢ Ensure that the internet browser does not use a proxy server, or at least not in case of addresses of direct access in the 10.10.x.x.-range. If you use the Microsoft Internet Explorer, you can check this by selecting the *Internet Options* command on the *Extra* browser menu. Click the *Connections* tab and click the *Settings* button in the *LAN-Settings* group field.
4. Enter spectrometer IP address into the browser address field (for stand-alone configuration: 10.10.0.1).
5. Click the *Enter* button.

   ➢ Now, the Internet Explorer should display the spectrometer firmware pages (see chapter 8). If the Internet Explorer shows a blank page, this indicates that the PC cannot access the spectrometer. A wrong spectrometer IP address may be the cause of the problem. Details on the IP address are described in chapter 9.2.
6. Close the Internet Explorer.

10 Connection Ports

10.1 Interlock and CAN bus

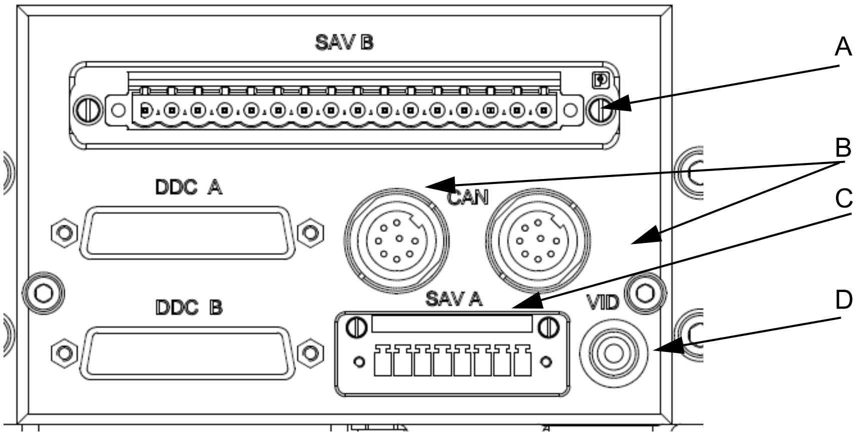


Figure 10.1: Interlock and CAN bus ports located on the rear spectrometer side

	Component	Definition
A	SAV B	16-pin plug, which is connected to the laser safety box in case of optional spectrometer configurations (chapter 11.1)
B	CAN bus connector	Connector used • to connect external automated units to the spectrometer. The CAN bus also provides power to these units. Thus, most external units can be operated without connecting them to the power supply. • as communication link to control these external units by the spectrometer
C	SAV A	8-pin plug, which is connected to the laser safety box in case of optional spectrometer configurations (chapter 11.1)
D	VID	Video accessory connector

Table 10.1: Definition of interlock and CAN bus ports located on the rear spectrometer side

10.2 Electronics panel and LEDs

The electronics panel on the spectrometer rear side includes cable connections (e.g. Ethernet connection) and LEDs which serve for the instrument diagnostics. Each LED indicates a specific operating status, e.g. interferometer mirror movement, data transfer etc.

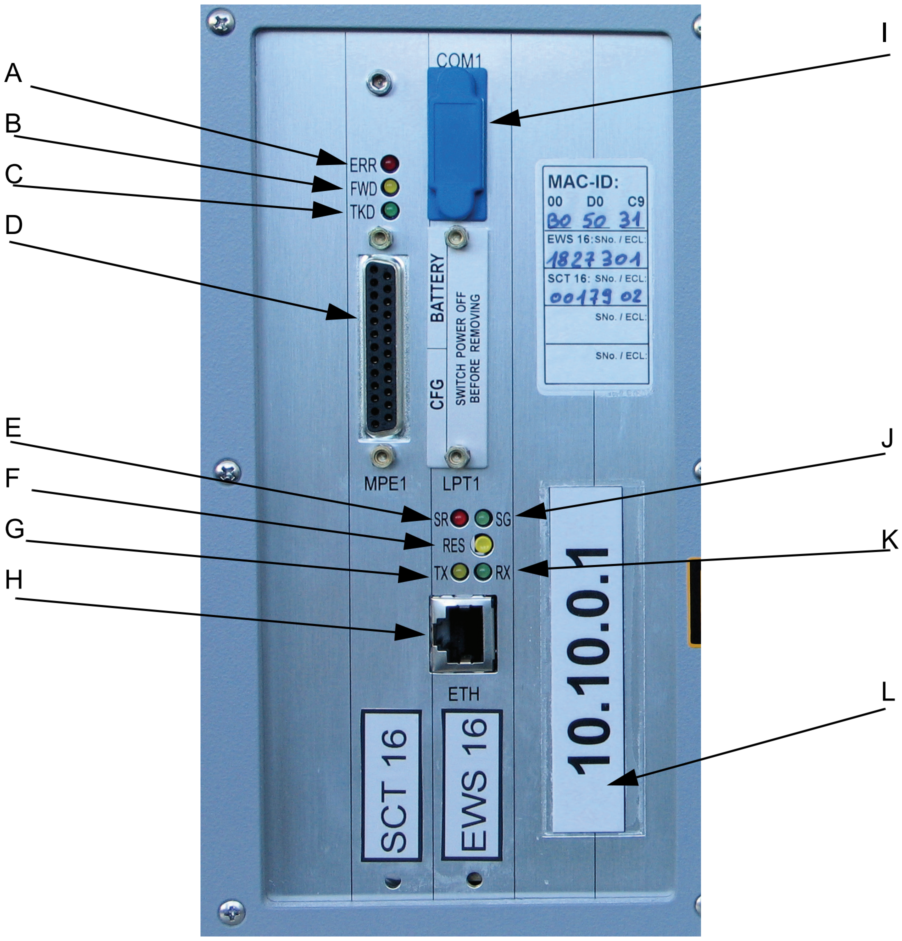


Figure 10.2: Electronics panel and LEDs located on the rear spectrometer side

	Component	Definition
A	ERR LED	**Red:** ➢ indicates an interferometer error, e.g. missing laser signal ➢ no data acquisition possible **Black:** ➢ Status OK The *ERR* abbreviation means *Error*.
B	FWD LED	**Yellow:** ➢ indicates the current interferometer mirror movement: mirror moves forward **Black:** ➢ indicates the current interferometer mirror movement: mirror moves backward **Flashing yellow:** ➢ during spectrometer operation ➢ LED flashes in the rhythm of the interferometer mirror forward and backward movement ➢ rhythm depends on the measurement parameters selected (e.g. resolution and velocity). The *FWD* abbreviation means *Forward*.
C	TKD LED	**Flashing green:** ➢ indicates that the interferometer mirror is within the data acquisition range ➢ typically, the TKD LED flashes with twice the frequency of the FWD LED and synchronous to the FWD LED ➢ during data acquisition the light intensity changes to bright green **Black:** ➢ no data acquisition The *TKD* abbreviation means *Take Data*.
D	MPE1 port	• allows to connect different types of external optical modules and DDC compatible detectors (DDC - Digital Detector Connection) • includes a complete CAN bus • transmits all required remote trigger signals

Table 10.2: Definition of electronic ports and LEDs located on the rear spectrometer side

	Component	Definition
E	SR LED	**Red:** ➢ spectrometer in boot process **Black:** ➢ internal operating status of spectrometer communication processor is OK ➢ communication via Ethernet possible The abbreviation *SR* means *Status Red*.
F	RES button	• similar to the RESET button known from a PC • pressing button → the effect is identical to switching the spectrometer off and on again • pressing button for more than 1 second → the spectrometer is reset without the need to turn it off • this button can be used to assign an IP address to the spectrometer
G	TX LED	**Yellow:** ➢ spectrometer transmits data, i.e. spectrometer is accessed by a PC ➢ Ethernet connection exists **Black:** ➢ No Ethernet connection available The *TX* abbreviation means *Transmit Data*.
H	ETH port	• used to connect the spectrometer to a PC or network • port is designed for RJ-45 plugs and complies with the 10/100Base-T Ethernet standard
I	COM1 port	• similar to a conventional, PC-compatible serial port • does not provide the complete functionality of a PC serial port • only used for special types of applications
J	SG LED	**Green:** ➢ internal operating status of spectrometer communication processor is OK **Black:** ➢ internal operating status of spectrometer communication processor is not OK The *SG* abbreviation means *Status Green*.

Table 10.2: Definition of electronic ports and LEDs located on the rear spectrometer side

	Component	Definition
K	RX LED	**Green:** ➢ data transfer between spectrometer and PC ➢ in case of stand-alone configuration (spectrometer to stand-alone PC): spectrometer receives data ➢ in case of spectrometer to Ethernet network configuration: data are transmitted via Ethernet **Black:** ➢ no data transfer between spectrometer and PC The *RX* abbreviation means *Receive Data*.
L	Spectrometer IP address	Label which shows the spectrometer IP address.

Table 10.2: Definition of electronic ports and LEDs located on the rear spectrometer side

10.3 Power supply ports and LEDs

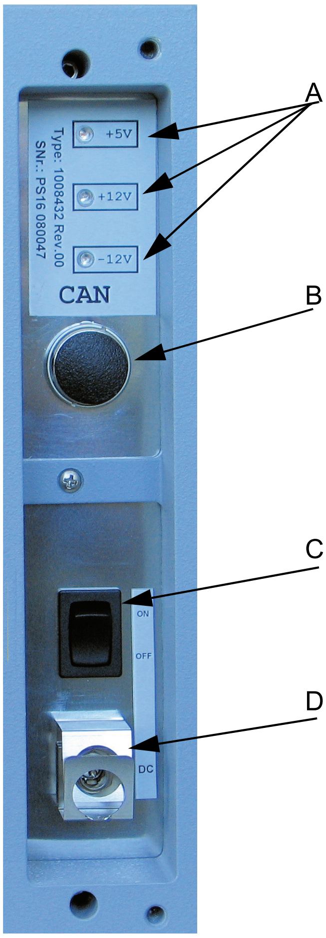


Figure 10.3: Power supply panel on spectrometer rear side

	Component	Definition
A	LEDs	• These LEDs indicate the status of the secondary voltages of the power supply unit. • Any dark power supply LED indicates a major problem with the spectrometer electronics. Details on this subject are described in chapter 7.5.1.1 et seq.
B	CAN bus connector	• allows to connect external automated units • allows to control (via spectrometer) these external units, and provide them with power supply The *CAN* abbreviation means *Controller Area Network*.

Table 10.3: Definition of power supply ports and LEDs on spectrometer rear side

	Component	Definition
C	Main power switch	➢ Spectrometer is switched on or off ➢ Switch interrupts or establishes the low-voltage supply **NOTE** **Spectrometer is switched on too quickly after it had been switched off** Blown fuses and /or damages on power supply switch ➢ If you have switched off the spectrometer, wait at least 30 seconds before switching it on again. This avoids peaks in the initial current.
D	Power port	The low-voltage socket is used to connect the low-voltage cable of the external power supply unit to the spectrometer.

Table 10.3: Definition of power supply ports and LEDs on spectrometer rear side

11 Options

11.1 Optional spectrometer configurations

Special types of accessories can optionally be connected to the MultiRAM spectrometer. Table 11.1 contains spectrometer configurations which are possible when connecting accessories to MultiRAM:

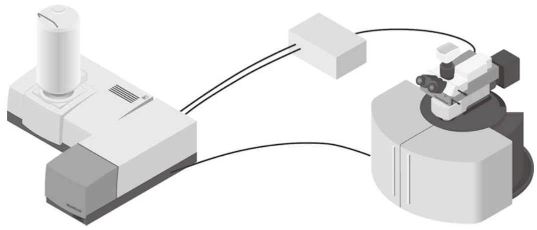
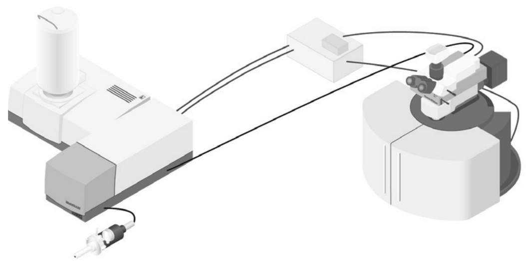
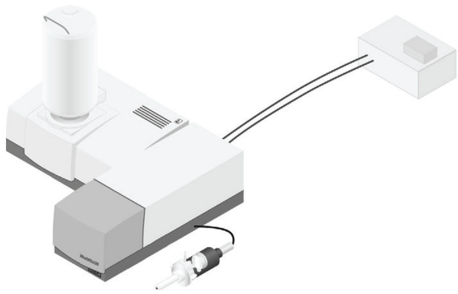
Optional spectrometer configurations	
MultiRAM with RamanScope III[a]	
MultiRAM with RamanScope III and fiber optical probe	
MultiRAM with fiber-optical probe	

Table 11.1: Optional spectrometer configurations

a. RamanScope III is an FT-Raman microscope.

11.2 Laser class

The MultiRAM spectrometer is a product of laser class 1 if no Raman accessories are connected which make laser radiation accessible to the user. If Raman accessories are connected to the spectrometer which make laser radiation accessible to the user, the spectrometer is a product of laser class 3B or 4. In the latter, protective measures must be taken according to EN 60825-1:10-2007[1].

Depending on the spectrometer configuration applied, the laser class classification changes due to ideally diffused or direct laser radiation as follows:

Spectrometer configuration	Laser class
MultiRAM with RamanScope III[a]	1
MultiRAM with RamanScope III and fiber-optical probe	• 3B[b] • 4[c]
MultiRAM with fiber-optical probe	• 3B[b] • 4[c]

Table 11.2: Laser class classification according to spectrometer configuration

a. To ensure that this kind of spectrometer configuration is a product of laser class 1 RamanScope III must be equipped with a laser-protective enclosure.

b. When using a laser type with a wavelength of 785 nm, or a wavelength of 1064 nm and a laser power <500 mW.

c. When using a laser type with a wavelength of 1064 nm and a laser power >500 mW.

Retrofitting the spectrometer requires changes with regard to the spectrometer configuration. Retrofitting is done by Bruker service only.

Details on laser safety are described in chapter 1.3.3.

1. Safety of laser products - Part 1: Equipment classification and requirements (IEC 60825-1:2007)

11.2.1 Raman accessories for laser class 1

Depending on the spectrometer configuration, a separate box (LK1)[1] is delivered for laser safety to comply with DIN EN 60825-1:2007. The box prevents laser radiation from being emitted in an uncontrolled manner when operating MultiRAM in connection with RamanScope III.

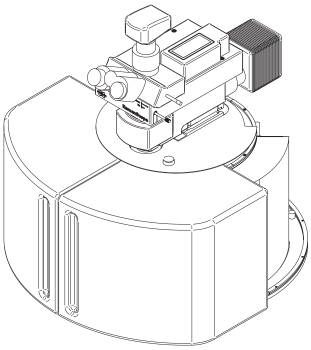
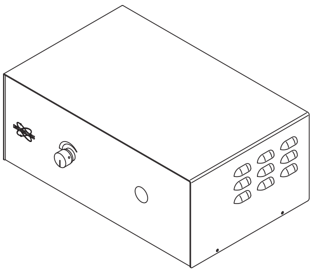
Accessory	Definition
	RamanScope III with laser-protective enclosure
	Laser safety box LK1 (chapter 4.5.1.3)

Table 11.3: Raman accessories for laser class 1

1. LK is the abbreviation for the German word *Laserklasse* (laser class).

11.2.2 Raman accessories for laser class 3B or 4

Depending on the spectrometer configuration, a separate box, including control box, is delivered for laser safety to comply with DIN EN 60825-1:2007. The boxes prevent laser radiation from being emitted in an uncontrolled manner when operating MultiRAM in connection with RamanScope III and/or fiber-optical probes.

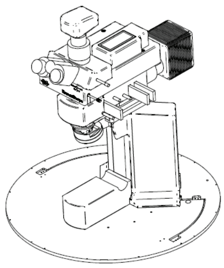
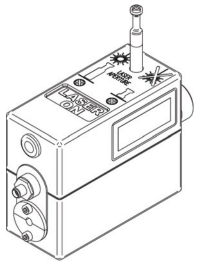
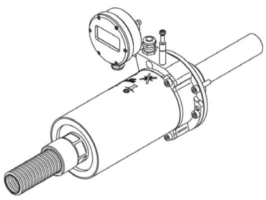
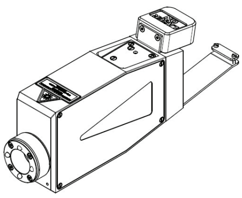
Accessory	Definition
	RamanScope III
	R361 fiber-optical probe
	R362 fiber-optical probe
	R265 fiber-optical probe with integrated video cam-era

Table 11.4: Raman accessories for laser class 3B or 4

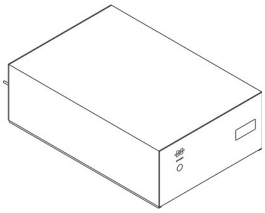
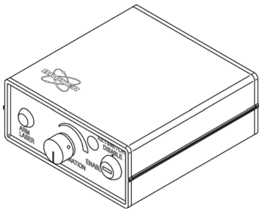
Accessory	Definition
	Laser safety box LK3B/4 (chapter 4.5.1.3)
	Control box[a] (chapter 4.5.1.3)

Table 11.4: Raman accessories for laser class 3B or 4

a. The control box controls the LK3B/4 box and the intensity of the halogen lamp inside RamanScope III.

11.3 Site requirements

According to EN 60825-14 a laser control location is required for Raman systems belonging to laser class 3B or 4, when there is the risk of foreseeable injury caused by laser radiation.

The laser control location needs to be clearly separated, identified and, if required, secured. Access must be limited to authorized personnel only, who has been instructed on laser safety.

If required, further information on how to install a laser control area can be requested from Bruker service.

11.3.1 Nominal hazard distance (NOHD)

In case of laser class 3B or 4, the Nominal Ocular Hazard Distance (NOHD) must be observed. This applies both for ideally diffused as well as for direct radiation. More details on this subject are described in chapter 1.3.4.

11.4 Installation

All hardware components required for the optional spectrometer configurations are connected and installed by Bruker service. If you have any questions about hardware installation, contact Bruker service (chapter 1.5).

11.5 MultiRAM with RamanScope III

In case of the spectrometer configuration MultiRAM with RamanScope III[1], the complete system is a product of laser class 1, provided RamanScope III is equipped with the laser-protective enclosure. The delivery contents contain the laser safety box (LK1), see chapter 11.2.1.

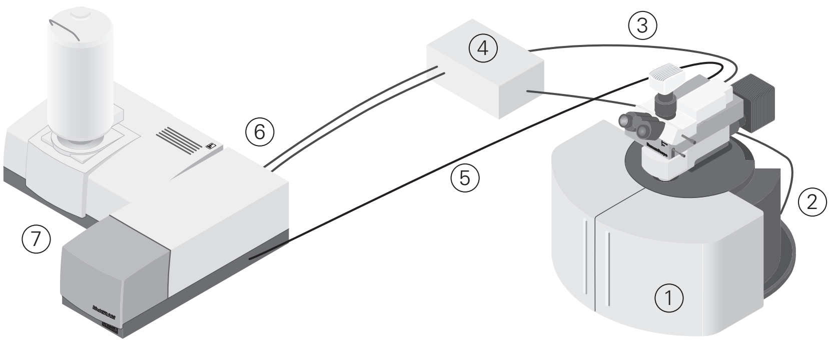


Figure 11.1: Spectrometer configuration MultiRAM with RamanScope III

	Definition
①	RamanScope III with laser-protective enclosure
②	Connecting cable between interlock function of the laser protective enclosure on RamanScope III, and the laser safety box LK1
③	Connecting cable between the SHUTTER connection port located on RamanScope III, and the laser safety box LK1
④	Laser safety box LK1
⑤	Connecting cable between MultiRAM and the connection port for the LASER ON display located on RamanScope III
⑥	Connecting cable between SAV A and B connection port located on MultiRAM and the laser safety box LK1
⑦	MultiRAM

Table 11.5: MultiRAM - Definition of spectrometer configuration MultiRAM with RamanScope III

1. Ramansope III is an FT-Raman microscope

11.5.1 Switching on MultiRAM and RamanScope III

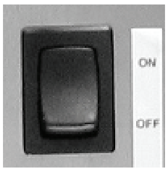
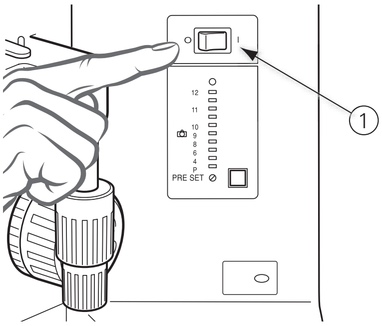
1		Turn the ON/OFF switch on MultiRAM into the ON position. ➢ The ON/OFF is located on the rear spectrometer side.
2		Press the O/I switch ① on RamanScope III. ➢ The O/I switch is located right next to the sample stage.
3	• Switch on PC. • Start OPUS. • On the *Login* dialog, select *FTRaman.ows* as assigned workspace from the appropriate drop-down list. • On the OPUS *Measure* menu, select the *Optic Setup and Service* command. Click the *Optical Bench* tab and initiate the connection between software and hardware.	
4	Press the O/I switch on the laser safety box LK1. ➢ The O/I switch is located on the rear side of the laser safety box LK1.	

Table 11.6: Switching on MultiRAM and RamanScope III

11.5.2 Loading measurement experiment in OPUS

1. On the OPUS *Measure* menu, select the *Setup Measurement Experiment* command.

   ➢ *The Setup Measurement Experiment dialog opens.*
2. Click the *Basic* tab.
3. Click the *Load* button and select the *RAMANSCOPE.XPM* experiment file from the dialog that opens.[1]
4. Click the *Accept & Exit* button.

i Always store an edited experiment file by a different file name to avoid software conflicts and/or errors during measurement.

1. By default, OPUS provides experiment files for the spectrometer configuration MultiRAM with RamanScope III. These experiment files have the file extension **.xpm* and contain the measuring parameters and settings which can be edited, if required. The default experiment files *MultiRAM.XPM* and *RAMANSCOPE.XPM* are stored in the *<OPUS>\XPM* directory. On the *Optic* tab, the experiment file contains the *Raman Compartmant* and *Right Exit* measurement channel options.

11.5.3 Activating automatic laser off[1]

1. On the OPUS *Measure* menu, select the *Advanced Measurement* command.
2. Click the *Basic* tab.
3. Activate the *Auto Laser OFF* checkbox.
4. Click the *Accept and Exit* button.
   ➣ *When the sample measurement has finished, the laser beam is automatically blocked, i.e. the beam is set to stand-by-mode.*

11.5.4 Checking signal

1. Position the sample.
2. Close the laser-protective enclosure on RamanScope III, and the sample compartment of MultiRAM.
3. On the OPUS *Measure* menu, select the *Advanced Measurement* command.
4. Click the *Check Signal* tab.
5. Adjust the x-axis and optimize laser power, if required.
6. Click the *Accept & Exit* button.

11.5.5 Starting sample measurement

1. On the OPUS *Measure* menu, select the *Advanced Measurement* command.[2]
2. Click the *Advanced* tab.
3. From the *Result spectrum* drop-down list, select the *Raman Spectrum* option.
4. Click the *Basic* tab.
5. Click the *Sample Raman Spectrum* button to start sample measurement.

1. By default, the *Auto Laser Off* checkbox is activated. If not, continue with steps 1 to 4.
2. To perform sample measurements using RamanScope III, you preferably select the *Video-assisted measurement* command in OPUS. Details on video-assisted measurement are described in the OPUS/VIDEO manual.

11.6 MultiRAM with RamanScope III and fiber-optical probe

In case of the spectrometer configuration MultiRAM with RamanScope III and fiber-optical probe, the complete system is a product of laser class 3B or 4, depending on the power of the laser used in the spectrometer (chapter 11.2). The delivery contents contain the laser safety box LK3B/4 (chapter 11.2.1).

The probe housing is equipped with a special probe cable. The probe cable has a plug-in connector which is connected to the probe port located on MultiRAM.

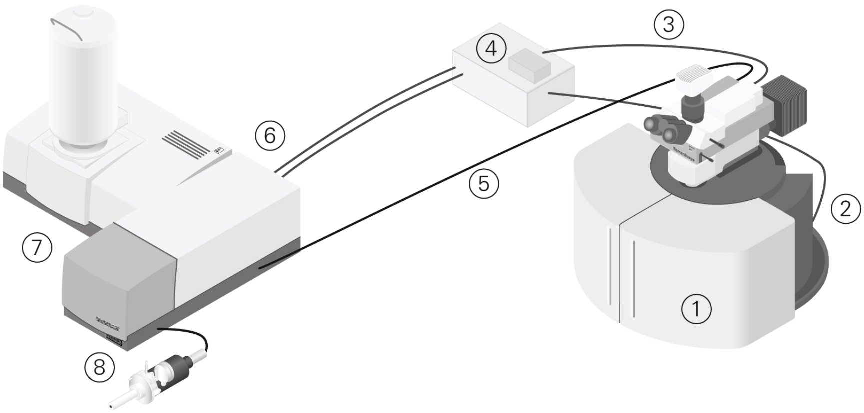


Figure 11.2: Spectrometer configuration MultiRAM with RamanScope III and fiber-optical probe

	Definition
1	RamanScope III with laser-protective enclosure
2	Connecting cable between interlock function of the laser protective enclosure on RamanScope III, and the laser safety box LK3B/4
3	Connecting cable between the connection port for the LASER ON display located on RamanScope III, and the laser safety box LK3B/4
4	Laser safety box LK3B/4 with control box
5	Connecting cable between MultiRAM and the SHUTTER connection port located on RamanScope III
6	Connecting cable between SAV A and B connection port located on MultiRAM and the laser safety box LK3B/4
7	MultiRAM
8	Fiber-optical probe

Table 11.7: MultiRAM - Definition of spectrometer configuration MultiRAM with RamanScope III and fiber-optical probe

11.6.1 Switching on MultiRAM and RamanScope III, activating laser on probe

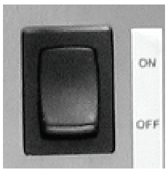
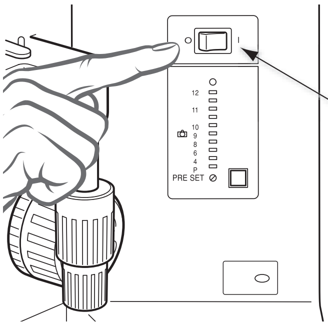
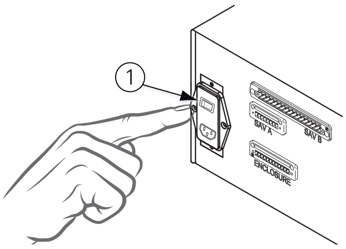
1		Turn the ON/OFF switch on MultiRAM into the ON position. ➢ The ON/OFF is located on the rear spectrometer side.
2		Press the O/I switch ① on RamanScope III. ➢ The O/I switch is located right next to the sample stage.
3	• Switch on PC. • Start OPUS. • On the *Login* dialog, select *FTRaman.ows* as assigned workspace from the appropriate drop-down list. • On the OPUS *Measure* menu, select the *Optic Setup and Service* command. Click the *Optical Bench* tab and initiate the connection between software and hardware.	
4		• Press the O/I switch ① on the laser safety box (LK3B/4). ➢ The O/I switch is located on the rear side of the LK3B/4 box. • Turn the key in horizontal position. ➢ The lock is located on the front side of the LK3B/4 box.
	i When using a Raman system classified as laser class 4 you have to push the ARMED LASER button on the front side of the control box to unblock the laser beam.	

Table 11.8: Switching on MultiRAM and RamanScope III, activating laser on probe

5	Pull out the laser shutter located on the housing of the FT-Raman probe to its outermost position. ➢ As soon as the LASER ON warning lamp on the probe housing is red, the laser is activated at the open probe end and laser radiation can emit. **⚠ WARNING** **Risk of emitting laser radiation** Serious (possibly irreversible) eye and skin injury ➢ Observe the safety instructions for laser radiation given in this user manual.

Table 11.8: Switching on MultiRAM and RamanScope III, activating laser on probe

11.6.2 Measuring sample using FT-Raman probe (R361 or R362)

The FT-Raman probe is connected to the MultiRAM spectrometer via a fiber optical cable.

11.6.2.1 Preparation

> ***NOTE***
>
> **Inappropriate handling of the probe**
>
> Serious, irreversible property damage
>
> ➢ Do not expose the probe to strong mechanical stress.
>
> ➢ Avoid contamination of the probe.

1. Put on safety goggles.
2. Activate the safety system within the laser control location.
3. Position sample within reach of the probe.

11.6.2.2 Loading measurement experiment in OPUS

1. On the OPUS *Measure* menu, select the *Setup Measurement Experiment* command.

   ➣ *The Setup Measurement Experiment dialog opens.*
2. Click the *Basic* tab.
3. Click the *Load* button and select the desired experiment file from the dialog that opens.[1]
4. Click the *Accept & Exit* button.

---

i Always store an edited experiment file by a different file name to avoid software conflicts and/or errors during measurement.

11.6.2.3 Activating automatic laser off[2]

1. On the OPUS *Measure* menu, select the *Advanced Measurement* command.
2. Click the *Basic* tab.
3. Activate the *Auto Laser OFF* checkbox.
4. Click the *Accept and Exit* button.

   ➣ *When the sample measurement has finished, the laser beam is automatically blocked, i.e. the beam is set to stand-by-mode.*

---

1. By default, OPUS provides experiment files for the spectrometer configuration MultiRAM with RamanScope III and fiber-optical probe. These experiment files have the file extension **.xpm* and contain the measuring parameters and settings which can be edited, if required. The default experiment files *MultiRAM.XPM* and *RAMANSCOPE.XPM* are stored in the *<OPUS>\XPM* directory. The following measurement channel options can be available in the experiment file: Raman Right Exit, Raman Compartment, Defocus, Front Exit. The *Defocus* option is used when the irradiance on the sample surface is too high. The *Front Exit* option is used for optical-fiber probes and the Raman Right Exit for the connected RamanScope III.
2. By default, the *Auto Laser Off* checkbox is activated. If not, continue with steps 1 to 4.

11.6.2.4 Checking signal

1. On the OPUS *Measure* menu, select the *Advanced Measurement* command.
2. Click the *Check Signal* tab.
3. Adjust the x-axis and optimize laser power, if required.
4. Click the *Accept & Exit* button.

11.6.2.5 Starting sample measurement

1. Pull out the laser shutter located on the housing of the FT-Raman probe to its outermost position.

⚠ WARNING

Risk of emitting laser radiation

Serious (possibly irreversible) eye and skin injury

➢ Observe the safety instructions for laser radiation given in this user manual.

2. On the OPUS *Measure* menu, select the *Advanced Measurement* command.
3. Click the *Advanced* tab.
4. From the *Result spectrum* drop-down list, select the *Raman Spectrum* option.
5. Click the *Basic* tab.
6. Click the *Sample Raman Spectrum* button to start sample measurement.

11.6.3 Measuring sample using video probe (R265)

The video probe with integrated video camera is connected to the MultiRAM spectrometer via a fiber optical cable.

i The laser on the video probe is activated, as soon as the LASER ON display on the probe housing lights red.

11.6.3.1 Preparation

NOTE

Inappropriate handling of the probe

Serious, irreversible property damage

➢ Do not expose the probe to strong mechanical stress.

➢ Avoid contamination of the probe.

1. Put on safety goggles.
2. Activate the safety system within the laser control location.
3. Position sample within reach of the probe.

11.6.3.2 Loading measurement experiment in OPUS

1. On the OPUS *Measure* menu, select the *Setup Measurement Experiment* command.

   ➢ *The Setup Measurement Experiment dialog opens.*
2. Click the *Basic* tab.
3. Click the *Load* button and select the desired experiment file from the dialog that opens.[1]
4. Click the *Accept & Exit* button.

i Always store an edited experiment file by a different file name to avoid software conflicts and/or errors during measurement.

1. By default, OPUS provides experiment files for the spectrometer configuration MultiRAM with RamanScope III and fiber-optical probe. These experiment files have the file extension **.xpm* and contain the measuring parameters and settings which can be edited, if required. The default experiment files *MultiRAM.XPM* and *RAMANSCOPE.XPM* are stored in the *<OPUS>\XPM* directory. The following measurement channel options can be available in the experiment file: Raman Right Exit, Raman Compartment, Defocus, Front Exit. The *Defocus* option is used when the irradiance on the sample surface is too high. The *Front Exit* option is used for optical-fiber probes and the Raman Right Exit for the connected RamanScope III.

11.6.3.3 Activating automatic laser off[1]

1. On the OPUS *Measure* menu, select the *Video Assisted Measurement* command.
2. Click the *Basic* tab.
3. Activate the *Auto Laser OFF* checkbox.
4. Click the *Accept and Exit* button.
   ➢ *When the sample measurement has finished, the laser beam is automatically blocked, i.e. the beam is set to stand-by-mode.*

11.6.3.4 Checking signal

1. On the OPUS *Measure* menu, select the *Video Assisted Measurement* command.
2. Click the *Check Signal* tab.
3. Use the *Excitation Laser Setpoint* slider to set the laser power.
   ➢ *Start with the lowest laser power to avoid damages on the sample.*
4. Click the *Accept & Exit* button.

11.6.3.5 Starting sample measurement

1. Pull out the laser regulator located on the housing of the FT-Raman probe to its outermost position.

WARNING

Risk of emitting laser radiation

Serious (possibly irreversible) eye and skin injury

➢ Observe the safety instructions for laser radiation given in this user manual.

2. On the OPUS *Measure* menu, select the *Video Assisted Measurement* command.
3. Click the *Advanced* tab.
4. From the *Result spectrum* drop-down list, select the *Raman Spectrum* option.
5. Click the *Basic* tab.
6. Click the *Start Video Assisted Measurement* button if 3D data should be recorded during the measurement.
   ➢ *If no 3D data are to be recorded during measurement, click the Set Measurement without 3D button.*

Detailed information on video-assisted measurement is described in the OPUS/VIDEO manual.

1. By default, the *Auto Laser Off* checkbox is activated. If not, continue with steps 1 to 4.

11.7 MultiRAM with fiber-optical probe

In case of the spectrometer configuration MultiRAM with a fiber-optical probe, the complete system is a product of laser class 3B or 4, depending on the wavelength and power of the laser used in the spectrometer (chapter 11.2). The delivery contents contain the laser safety box LK3B/4 (chapter 11.2.1).

The probe housing is equipped with a special probe cable. The probe cable has a plug-in connector which is connected to the probe port located on MultiRAM.

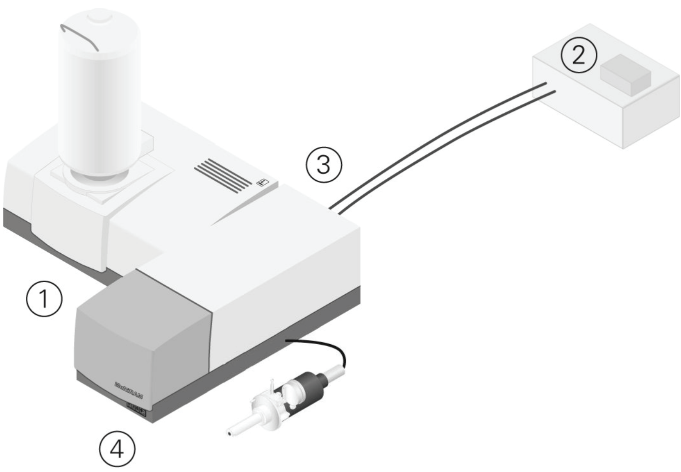


Figure 11.3: Spectrometer configuration MultiRAM with fiber-optical probe

	Definition
①	MultiRAM
②	Laser safety box LK3B/4 with control box
③	Connecting cable between SAV A and B connection port located on MultiRAM and the laser safety box LK3B/4
④	Fiber-optical probe

Table 11.9: MultiRAM - Definition of spectrometer configuration MultiRAM with fiber-optical probe

11.7.1 Switching on MultiRAM and activating laser on probe

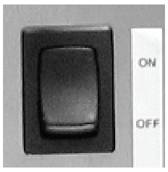
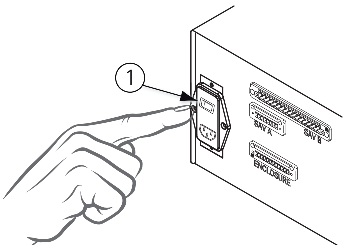
<table>
<tr><td>1</td><td>
</td><td>Turn the ON/OFF switch on MultiRAM into the ON position.
➢ The ON/OFF is located on the rear spectrometer side.</td></tr>
<tr><td>2</td><td colspan="2">• Switch on PC.
• Start OPUS.
• On the Login dialog, select FTRaman.ows as assigned workspace from the appropriate drop-down list.
• On the OPUS Measure menu, select the Optic Setup and Service command. Click the Optical Bench tab and initiate the connection between software and hardware.</td></tr>
<tr><td rowspan="2">3</td><td>
</td><td>• Press the O/I switch ① on the laser safety box LK3B/4.
➢ The O/I switch is located on the rear side of the LK3B/4 box.
• Turn the key in horizontal position.
➢ The lock is located on the front side of the LK3B/4 box.</td></tr>
<tr><td colspan="2">ℹ When using a Raman system classified as laser class 4 you have to push the ARMED LASER button on the front side of the control box to unblock the laser beam.</td></tr>
<tr><td>4</td><td colspan="2">Pull out the laser shutter located on the housing of the FT-Raman probe to its outermost position.
➢ As soon as the LASER ON warning lamp on the probe housing is red, the laser is activated at the open probe end and laser radiation can emit.
⚠ WARNING
Risk of emitting laser radiation
Serious (possibly irreversible) eye and skin injury
➢ Observe the safety instructions for laser radiation given in this user manual.</td></tr>
</table>

Table 11.10: Switching on MultiRAM and activating laser on probe

11.7.2 Measuring sample using FT-Raman probe (R361 or R362)

The FT-Raman probe is connected to the MultiRAM spectrometer via a fiber optical cable.

11.7.2.1 Preparation

NOTE

Inappropriate handling of the probe

Serious, irreversible property damage

➢ Do not expose the probe and fibers to strong mechanical stress.

➢ Avoid contamination of the probe.

1. Put on safety goggles.
2. Activate the safety system within the laser control location.
3. Position sample within reach of the probe.

11.7.2.2 Loading measurement experiment in OPUS

1. On the OPUS *Measure* menu, select the *Setup Measurement Experiment* command.
   ➢ *The Setup Measurement Experiment dialog opens.*
2. Click the *Basic* tab.
3. Click the *Load* button and select the desired experiment file from the dialog that opens.[1]
4. Click the *Accept & Exit* button.

i Always store an edited experiment file by a different file name to avoid software conflicts and/or errors during measurement.

1. By default, OPUS provides experiment files for the spectrometer configuration MultiRAM with fiber-optical probe. These experiment files have the file extension **.xpm* and contain the measuring parameters and settings which can be edited, if required. The default experiment files *MultiRAM.XPM*, *RAMAN.XPM* and *RAMANSCOPE.XPM* are stored in the *<OPUS>\XPM* directory. On the *Optic* tab, the experiment file contains the *Right Exit* measurement channel.

11.7.2.3 Activating automatic laser off[1]

1. On the OPUS *Measure* menu, select the *Advanced Measurement* command.
2. Click the *Basic* tab.
3. Activate the *Auto Laser OFF* checkbox.
4. Click the *Accept and Exit* button.
   ➢ *When the sample measurement has finished, the laser beam is automatically blocked, i.e. the beam is set to stand-by-mode.*

11.7.2.4 Checking signal

5. On the OPUS *Measure* menu, select the *Advanced Measurement* command.
6. Click the *Check Signal* tab.
7. Adjust the x-axis and optimize laser power, if required.
8. Click the *Accept & Exit* button.

11.7.2.5 Starting sample measurement

1. Pull out the laser shutter located on the housing of the FT-Raman probe to its outer-most position.

WARNING

Risk of emitting laser radiation

Serious (possibly irreversible) eye and skin injury

➢ Observe the safety instructions for laser radiation given in this user manual.

2. On the OPUS *Measure* menu, select the *Advanced Measurement* command.
3. Click the *Advanced* tab.
4. From the *Result spectrum* drop-down list, select the *Raman Spectrum* option.
5. Click the *Basic* tab.
6. Click the *Sample Raman Spectrum* button to start sample measurement.

1. By default, the *Auto Laser Off* checkbox is activated. If not, continue with steps 1 to 4.

11.7.3 Measuring sample using video probe (R265)

The video probe with integrated video camera is connected to the MultiRAM spectrometer via a fiber optical cable.

11.7.3.1 Preparation

NOTE

Inappropriate handling of the probe

Serious, irreversible property damage

➢ Do not expose the probe and fibers to strong mechanical stress.

➢ Avoid contamination of the probe.

1. Put on safety goggles.
2. Activate the safety system within the laser control location.
3. Position sample within reach of the probe.

11.7.3.2 Loading measurement experiment in OPUS

1. On the OPUS *Measure* menu, select the *Setup Measurement Experiment* command.
   ➢ *The Setup Measurement Experiment dialog opens.*
2. Click the *Basic* tab.
3. Click the *Load* button and select the desired experiment file from the dialog that opens.[1]
4. Click the *Accept & Exit* button.

ℹ Always store an edited experiment file by a different file name to avoid software conflicts and/or errors during measurement.

1. By default, OPUS provides experiment files for the spectrometer configuration MultiRAM with RamanScope III and fiber-optical probe. These experiment files have the file extension **.xpm* and contain the measuring parameters and settings which can be edited, if required. The default experiment files *MultiRAM.XPM* and *RAMANSCOPE.XPM* are stored in the *<OPUS>\XPM* directory. On the *Optic* tab, the experiment file contains the *Right Exit* measurement channel.

11.7.3.3 Activating automatic laser off[1]

1. On the OPUS *Measure* menu, select the *Video Assisted Measurement* command.
2. Click the *Basic* tab.
3. Activate the *Auto Laser OFF* checkbox.
4. Click the *Accept and Exit* button.
   ➢ *When the sample measurement has finished, the laser beam is automatically blocked, i.e. the beam is set to stand-by-mode.*

11.7.3.4 Checking signal

1. On the OPUS *Measure* menu, select the *Video Assisted Measurement* command.
2. Click the *Check Signal* tab.
3. Use the *Excitation Laser Setpoint* slider to set the laser power.
   ➢ *Start with the lowest laser power to avoid damages on the sample.*
4. Click the *Accept & Exit* button.

11.7.3.5 Starting sample measurement

1. Pull out the laser shutter located on the housing of the FT-Raman probe to its outermost position.

WARNING

Risk of emitting laser radiation

Serious (possibly irreversible) eye and skin injury

➢ Observe the safety instructions for laser radiation given in this user manual.

2. On the OPUS *Measure* menu, select the *Video Assisted Measurement* command.
3. Click the *Advanced* tab.
4. From the *Result spectrum* drop-down list, select the *Raman Spectrum* option.
5. Click the *Basic* tab.
6. Click the *Start Video Assisted Measurement* button if 3D data should be recorded during the measurement.
   ➢ *If no 3D data are to be recorded during measurement, click the Set Measurement without 3D button.*

Detailed information on video-assisted measurement is described in the OPUS/VIDEO manual.

1. By default, the *Auto Laser Off* checkbox is activated. If not, continue with steps 1 to 4.

11.8 MultiRAM with temperature-controlled sample stage

In case of the spectrometer configuration MultiRAM with a temperature-controlled sample stage, the complete system is a product of laser class 1.

When dismounting the temperature-controlled sample stage, a special cover plate has to be fixed on the right side of the sample compartment lid. This cover plate prevents laser radiation from being emitted out of the sample compartment.

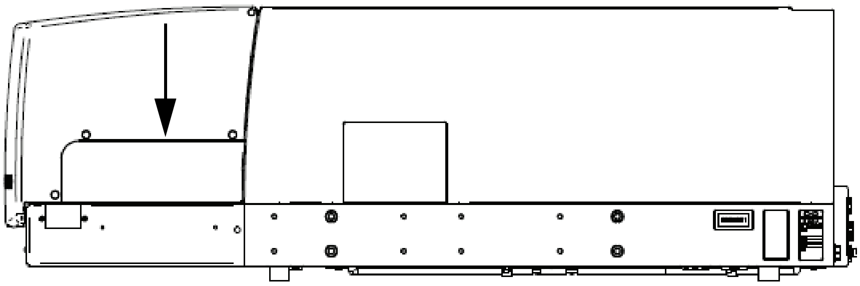


Figure 11.4: MultiRAM with cover plate on the right side of the sample compartment when temperature-controlled sample stage is dismounted

11.8.1 Switching on MultiRAM and activating temperature control

<table>
<tr><td>1</td><td></td><td>Turn the ON/OFF switch on MultiRAM into the ON position.
➢ The ON/OFF is located on the rear spectrometer side.</td></tr>
<tr><td>2</td><td colspan="2">• Switch on PC.
• Start OPUS.
• On the Login dialog, select FTRaman.ows as assigned workspace from the appropriate drop-down list.
• On the OPUS Measure menu, select the Optic Setup and Service command. Click the Optical Bench tab and initiate the connection between software and hardware.</td></tr>
<tr><td>3</td><td colspan="2">The desired temperature can be set as follows:
• by using the OPUS software:
☞ On the OPUS Measure menu, select the Temperature Control command. More details are described in the OPUS Reference Manual.
• manually by using the Eurotherm temperature controller. More details are described in the supplied Eurotherm Installation and Operation Handbook.
• by using the LinkSys temperature control software provided by Linkam. More details are described in the supplied Linkam documentation.</td></tr>
</table>

Table 11.11: Switching on MultiRAM and activating temperature control

CAUTION

Risk of burn and/or frostbite

Personal injury

➢ Always wait until the sample holder is cooled down or warmed up to room temperature, before touching the sample holder or the sample.

NOTE

Danger caused by inappropriate operation

Severe property damage

➢ The windows of the temperature-controlled sample holder are made of quartz, are very thin and can easily be damaged. Be very careful when using this type of sample holder and observe the applied health and safety conditions.

11.8.2 Loading measurement experiment in OPUS

1. On the OPUS *Measure* menu, select the *Setup Measurement Experiment* command.

   ➢ *The Setup Measurement Experiment dialog opens.*
2. Click the *Basic* tab.
3. Click the *Load* button and select the desired experiment file from the dialog that opens.[1]
4. Click the *Accept & Exit* button.

Always store an edited experiment file by a different file name to avoid software conflicts and/or errors during measurement.

1. By default, OPUS provides experiment files for the spectrometer configuration MultiRAM with fiber-optical probe. These experiment files have the file extension **.xpm* and contain the measuring parameters and settings which can be edited, if required. The default experiment files *MultiRAM.XPM, RAMAN.XPM* and *RAMANSCOPE.XPM* are stored in the *<OPUS>\XPM* directory. On the *Optic* tab, the experiment file contains the *Raman Compartment* measurement channel.

11.8.3 Activating automatic laser off[1]

1. On the OPUS *Measure* menu, select the *Advanced Measurement* command.
2. Click the *Basic* tab.
3. Activate the *Auto Laser OFF* checkbox.
4. Click the *Accept and Exit* button.
   ➢ *When the sample measurement has finished, the laser beam is automatically blocked, i.e. the beam is set to stand-by-mode.*

11.8.4 Checking signal

1. Position the sample.
2. Close the sample compartment of MultiRAM.
3. On the OPUS *Measure* menu, select the *Advanced Measurement* command.
4. Click the *Check Signal* tab.
5. Adjust the x-axis and optimize laser power, if required.
6. Click the *Accept & Exit* button.

11.8.5 Starting sample measurement

1. On the OPUS *Measure* menu, select the *Advanced Measurement* command.
2. Click the *Advanced* tab.
3. From the *Result spectrum* drop-down list, select the *Raman Spectrum* option.
4. Click the *Basic* tab.
5. Click the *Sample Raman Spectrum* button to start sample measurement.

1. By default, the *Auto Laser Off* checkbox is activated. If not, continue with steps 1 to 4.

A Specifications

A.1 General

Parameter	Specification
Dimension	• Complete spectrometer: 96.8 x 86.1 x 27.8 cm (w x d x h) • Sample compartment: 27 x 19 x 25 cm (w x d x h)
EMI regulations	Complies with EN 61326-1:2006 (*Electrical equipment for measurement, control and laboratory use - EMC requirements*)
Environmental conditions[a]	• Operational temperature range: 5 - 35°C • Temperature variation: max. 1°C/ per hour and max. 2°C per day • Humidity (non-condensing): less than 80% (relative humidity) • Installation site: in a closed room, max. 2000 m above sea level • Pollution degree: 2, complies with 61010-1 or IEC 60664-1
Laser class 1 product according to DIN EN 60825-1:10-2007	See chapter 1.3.3.1
Laser class 3B or 4 product according to DIN EN 60825-1:10-2007	See chapter 1.3.3.2
Possible laser types	λ = 1064 nm $P_{max} \leq 0.5, 1.0$ W divergence angle: 2 mrad λ = 785 nm $P_{max} \leq 0.5$ W divergence angle: 2.8 mrad
Overvoltage category	II, complies with 61010-1 or IEC 60664-1
Power consumption	Typical: 75 W Maximum: 180 W

Table A.1: Specifications - General

Parameter	Specification
Power supply	Maximum: 100 - 240VAC, 50 - 60Hz (Installation complies with VDE 0100 or IEC 60364)
Safety regulations	• Complies with EN/IEC 61010-1:2010 (*Safety requirements for electrical equipment for measurement, control and laboratory use*) • Complies with EN 60825-1:2007 (*Safety requirements for laser equipment*)
Weight	72 kg, standard configuration

Table A.1: Specifications - General

a. The values indicated are target values which have an effect on the performance of the entire configuration. In case of non-observance the functioning and safety of the configuration may be affected adversely.

A.2 Performance

Parameter	Specification
Resolution	Standard: better than 0.8 cm^{-1}
Spectral range	• 3600 - 70 cm^{-1} stokes shift (RT-InGaAs detector) • 3500 - 70 cm^{-1} stokes shift (Ge detector) • option: 50 cm^{-1}
Wavenumber accuracy	0.1 cm^{-1}

Table A.2: Specifications - Performance

A.3 Optics

Parameter	Specification
Collection optics	High-throughput 180° collection lens standard
Design	Stand-alone FT-Raman spectrometer with sealed optics housing, purgeable

Table A.3: Specifications - Optics

Parameter	Specification
Detector	• InGaAs (room temperature, high sensitivity) • Ge (cooled by liquid nitrogen) • Si-avalanche (thermoelectrically stabilized)
Interferometer	Mechanical ROCKSOLID interferometer, permanently aligned
Sampling	Pre-aligned sample stage with PC-controlled z-positioning
Source	• White light source for Raman background correction • Built-in alignment lamp for sample alignment and calibration • Laser

Table A.3: Specifications - Optics

A.4 Spectroscopy software

Parameter	Specification
Name	OPUS
Operating system required	Windows 7 or Windows XP
21 CFR Part 11	conform
GMP/GLP	conform
Additional OPUS software packages recommended	• **OPUS/MAP:** grid measurements on pre-defined measuring positions (only in connection with a motorized XYZ stage) • **OPUS/VIDEO:** video-assisted measurements (only in connection with a motorized XYZ stage) • **OPUS/VALIDATION:** working in validated mode according to 21 CFR Part 11

Table A.4: Specifications - Spectroscopy software

B Spare Parts

Part No.	Description
82329	Reference lamp
Q101/B	HeNe laser module

Table B.1: Spare parts

B.1 Sampling kit

The MultiRAM spectrometer is supplied with a standard sampling kit. The kit contents may vary in some cases. In general, the kit contains:

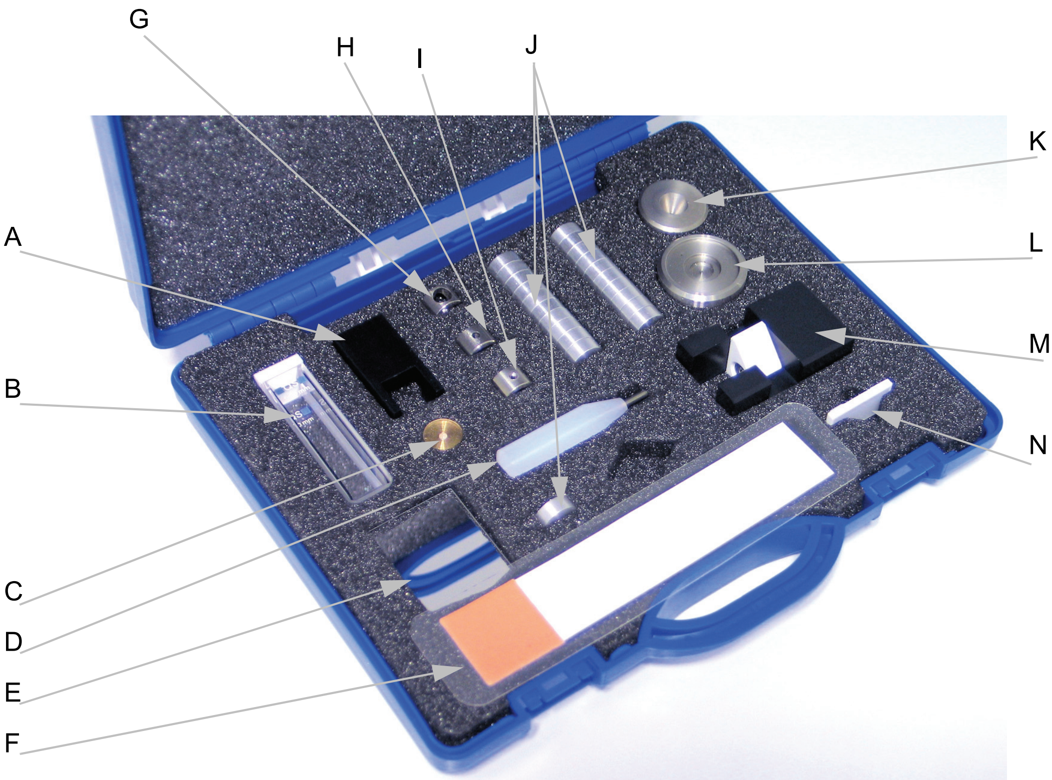


Figure B.1: MultiRAM - Sampling kit

	Definition
A	Holder for quartz cuvette
B	Quartz cuvette, 0.5 cm, backside mirrored
C	Naphthalene test sample for test of wavenumber accuracy
D	Pestle for pressing sample into aluminium disc, in combination with use of funnel (K + L)
E	Flat aluminium mirror
F	Indicator card for NIR laser radiation
G	Holder for NMR tube, d=4 mm
H	Holder for melting tube, d=1.5 mm
I	Holder for melting tube, d=1.0 mm
J	Aluminium discs (sample container)
K	Funnel for aluminium disc
L	Base plate for funnel
M	Reflector for tungsten lamp (reference lamp)
N	Polystyrene for test of signal/noise ratio

Table B.2: Definition of the single sample kit components

C Default Parameter Settings

Before starting a measurement, you have to enter appropriate measurement parameter values, or select the corresponding parameter setting options in OPUS[1]. The optics parameter values and settings depend on the spectrometer configuration selected. The following table lists only the parameter values and settings for the standard spectrometer configuration.

Standard spectrometer configuration means that the spectrometer is equipped with an InGAas detector. If the spectrometer is equipped with optional components, make sure that you select the correct optics parameters for *Detector*.

C.1 Setting up parameters

1. On the OPUS *Measure* menu, select the *Advanced Measurement* command.
2. On the *Advanced*, *Optic*, *Acquisition* and *FT* tabs, define the respective parameters.
3. Save the settings made.

C.2 Measurement parameters for standard configuration

Advanced parameters	**Settings**
Resolution	4 cm^{-1} (typical)
Sample scan	64
Save data from...to	4000 ... 0cm^{-1}
Data blocks to be saved	Raman
Optics parameters	**Settings**
Source setting	Laser
Aperture setting	5 mm
Measurement channel	Raman Compartment
Detector setting	LN-Ge diode
Scanner velocity	5 kHz

Table C.1: Measurement parameters for standard configuration

1. OPUS is the spectroscopy software developed by Bruker

Sample/Background signal gain	x1
Signal gain	Off
Delay after device change	0 sec.
Delay before measurement	0 sec.
Acquisition parameters	**Settings**
Wanted high frequency limit	30,000 cm^{-1}
Wanted low frequency limit	0 cm^{-1}
High pass filter	On
Low pass filter	LPF= on (5 kHz)
Acquisition mode	Double Sided, Forward/Backward
Correlation mode	Raman
FT parameters	**Settings**
Phase resolution	Power/No Peak Search
Phase correction mode	Power Spectrum
Apodisation function	Blackman-Harris B4
Zerofilling factor	2

Table C.1: Measurement parameters for standard configuration

D Dimensional Drawings

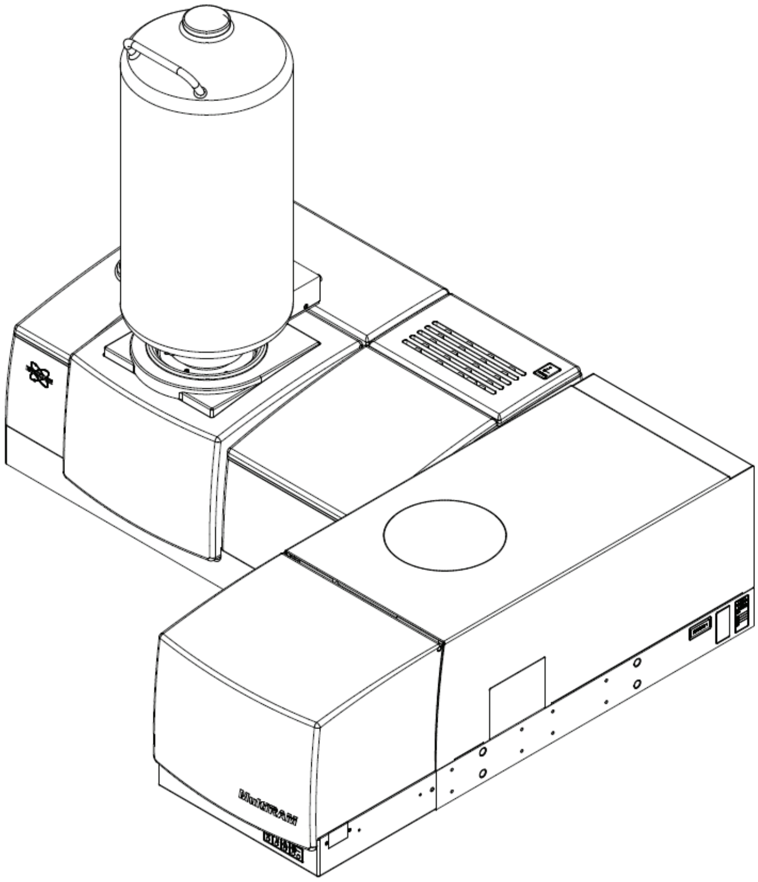


Figure D.1: MultiRAM -Isometric view with sample compartment closed

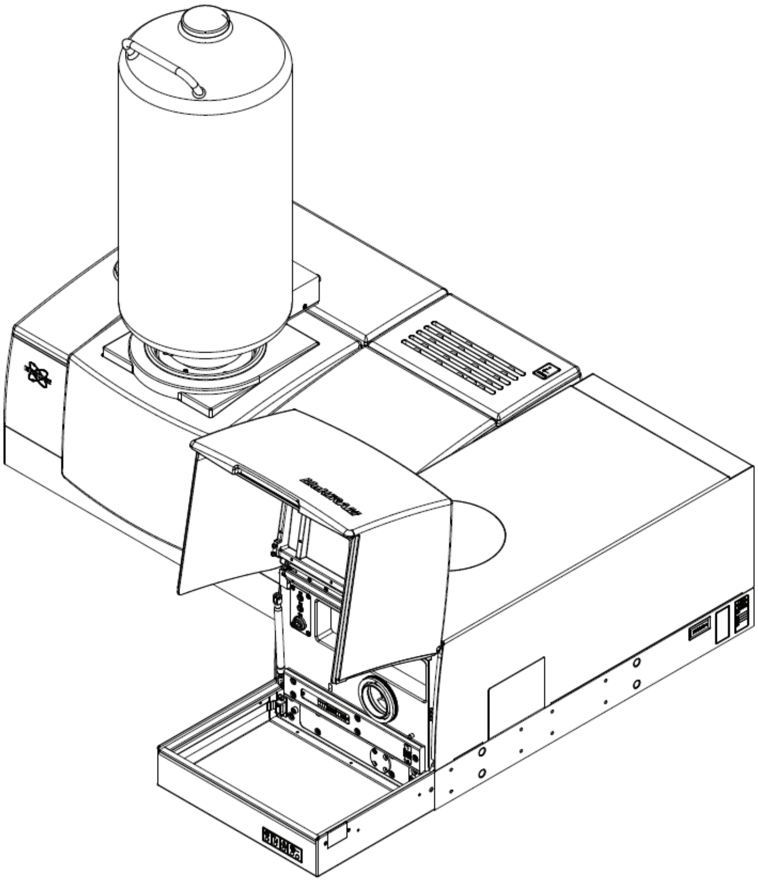


Figure D.2: MultiRAM - Isometric view with sample compartment open

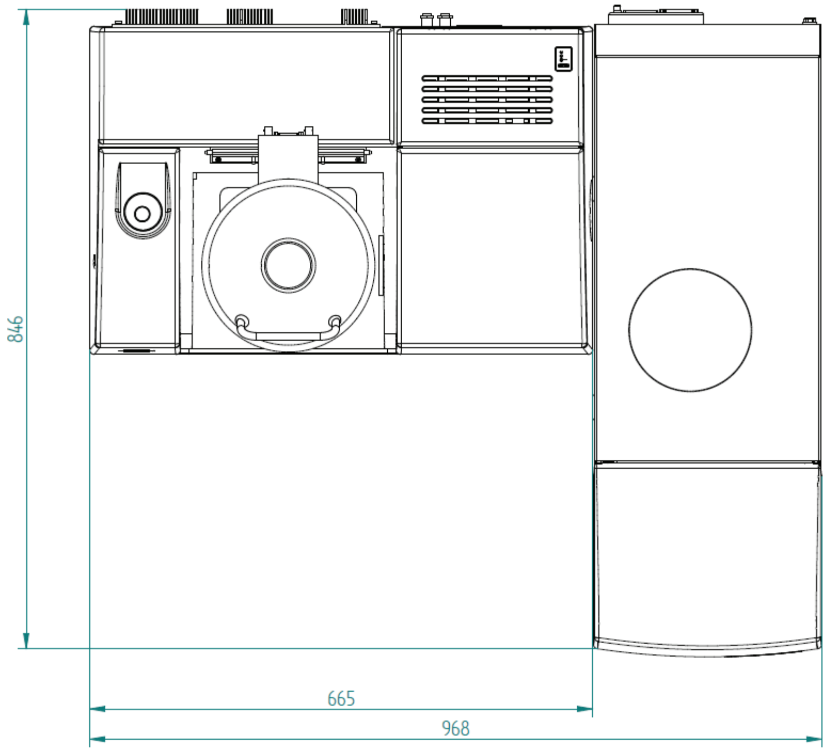


Figure D.3: MultiRAM - Top side view (dimensions in mm)

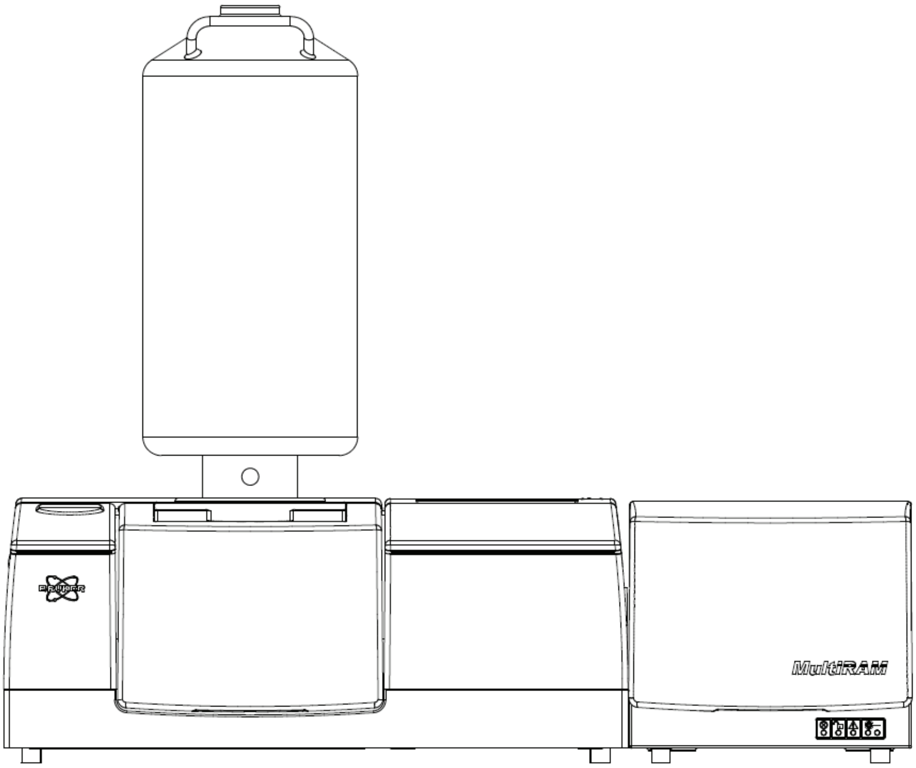


Figure D.4: MultiRAM - Front view

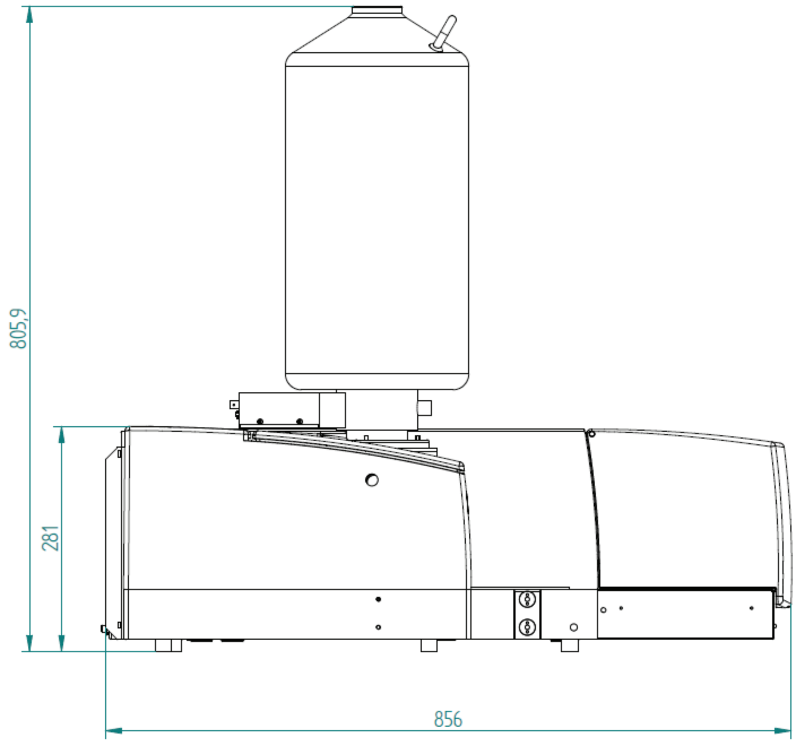


Figure D.5: MultiRAM - Left side view (dimensions in mm)

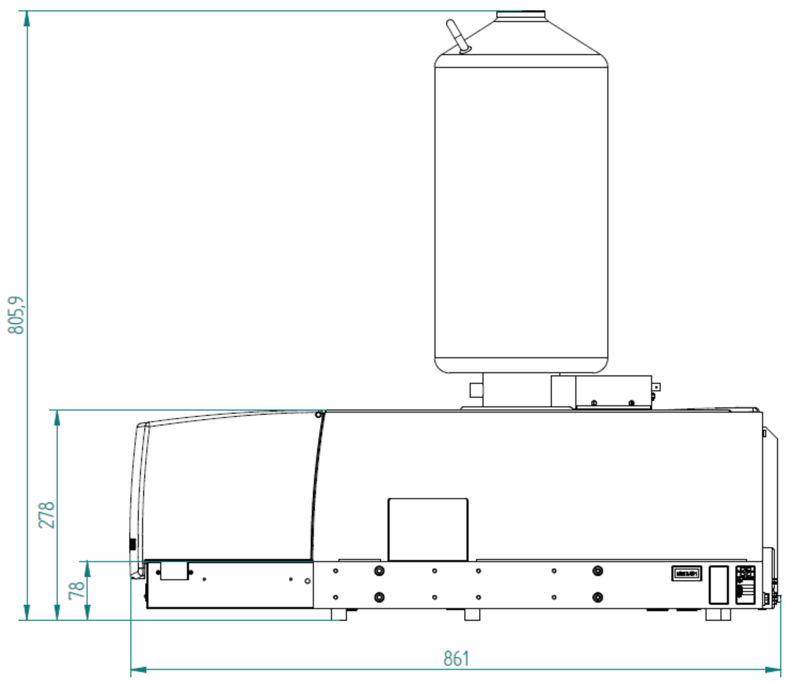


Figure D.6: MultiRAM - Right side view (dimensions in mm)

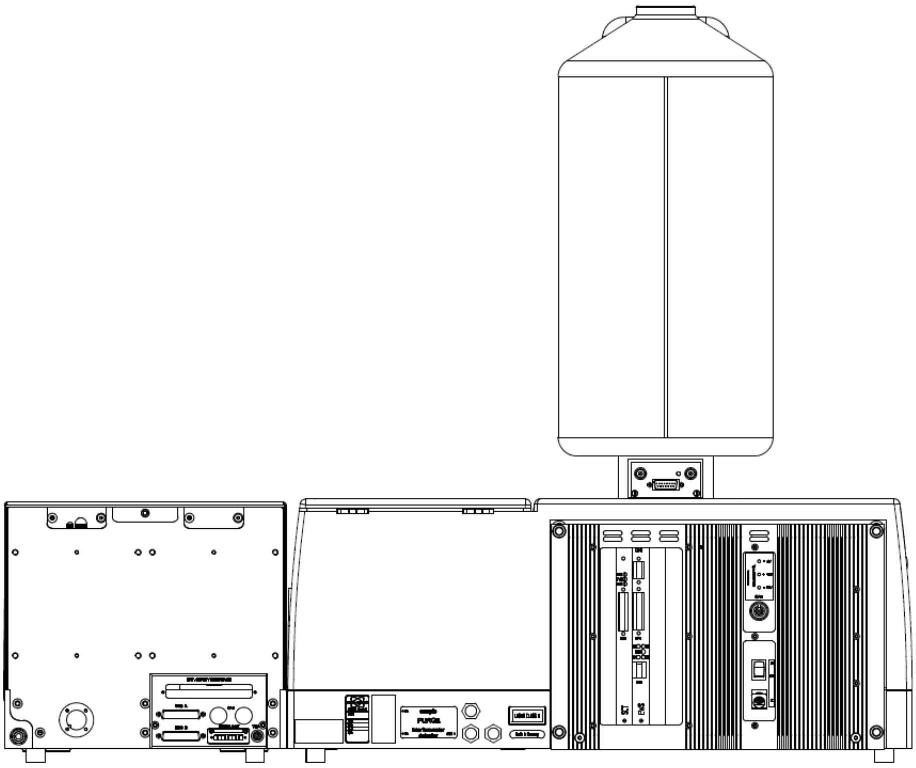


Figure D.7: MultiRAM - Rear side view

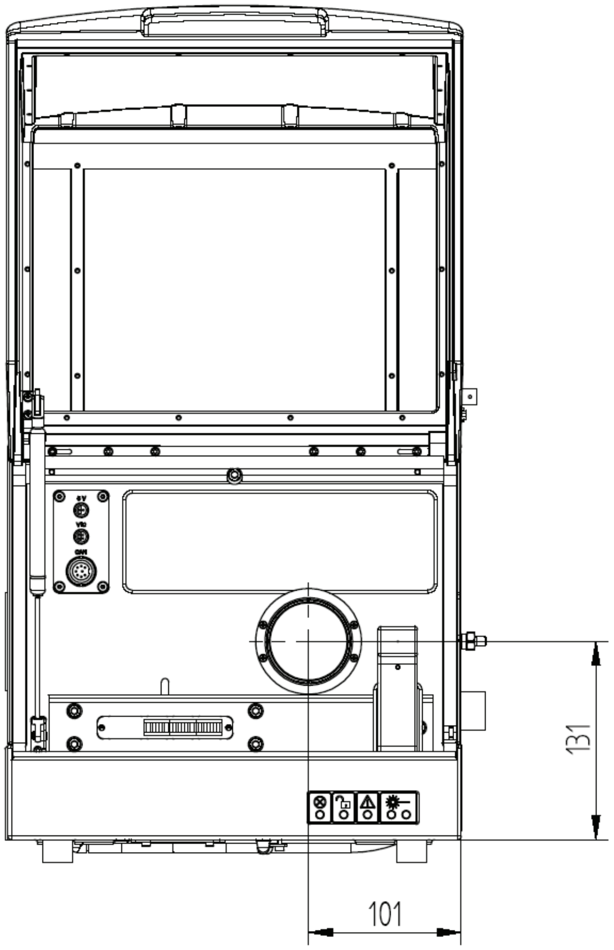


Figure D.8: MultiRAM - Sample compartment front view with front lid being open

Dimensional Drawings D

E Firmware Update

The spectrometer firmware needs to be updated in order to make new features available. The update is performed by using the FCONF program (Firmware Configuration Tool). This program performs all the necessary actions automatically.

The FCONF program allows:

- updating the firmware
- restoring a previous firmware version
- backing up the current firmware version
- initializing the firmware (for service purposes only!)
- running a custom script (for service purposes only!)

Typically, firmware updates are delivered on CD or by e-mail. The delivered firmware update performs all the actions required to properly substitute the existing firmware version.

---

i Before the firmware update, restoration or initialization starts, backup copies of the previous firmware version are generated automatically, and stored in the *Backup* program folder.

E.1 Firmware update on CD

1. Start the FCONF program directly from CD.
2. Double click the *fconf.exe* file.
3. Proceed as described in chapter E.3.

E.2 Firmware update via E-mail

1. Store the delivered files into a temporary directory.
2. Start the FCONF program by double-clicking the *fconf.exe* file
3. Proceed as described in chapter E.3.

The following dialog opens:

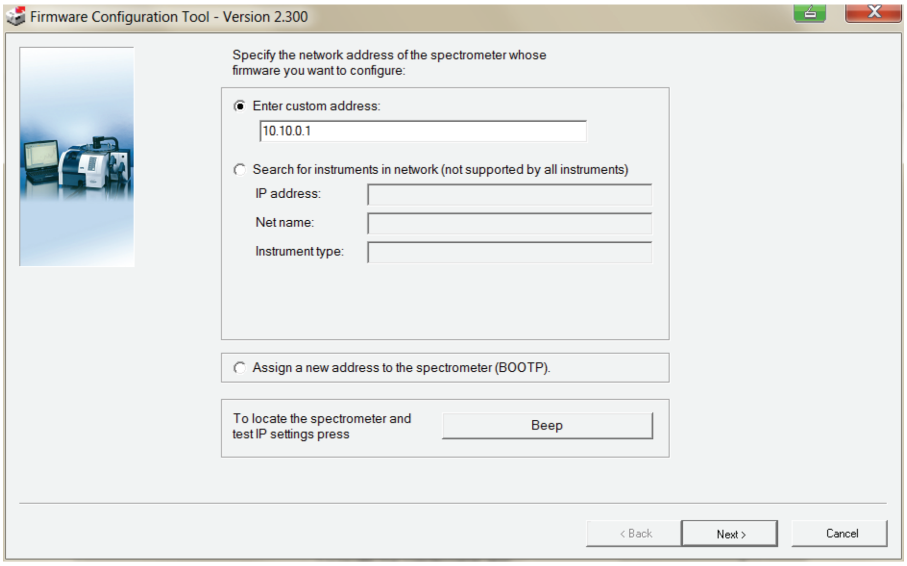


Figure E.1: Program FCONF - Firmware Update

E.3 Performing firmware update

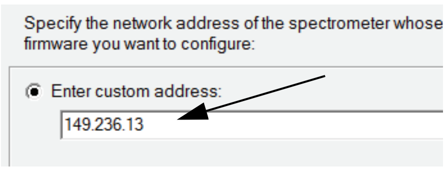
1		• Activate the *Enter custom address* option button. • Enter the IP address in dotted notation. i In case of a stand-alone spectrometer configuration, the default IP address is 10.10.0.1. If the spectrometer is directly integrated into a network, it must have a different IP address. In this case use the IP address labeled on the spectrometer rear side. The operating company is obliged to write the IP address on the label provided on the spectrometer rear side.
2	• Check whether the spectrometer desired is recognized by the firmware. ☞ Click the *Beep* button. If the spectrometer beeps three times in rapid succession (once in case of ALPHA), it has been recognized by the firmware. • Click the *Next* button.	

Table E.1: Updating firmware

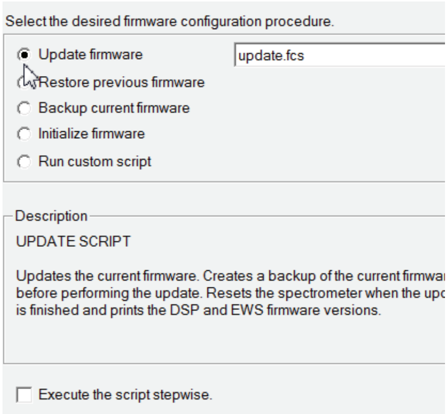
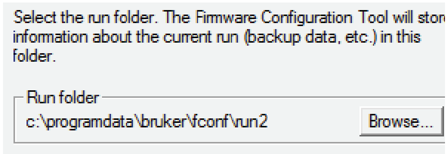
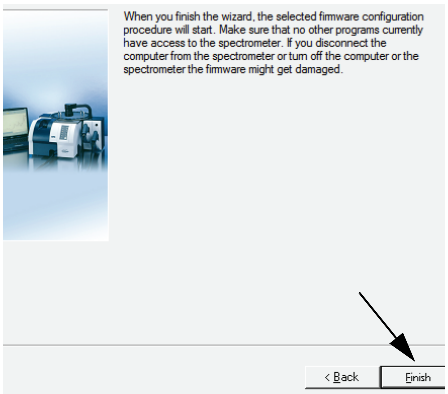
3		• Activate *Update firmware* option button. • Click the *Next* button.
4		• Either accept the default directory setting or define a different path by clicking the *Browse* button. • Click the *Next* button.
5		Click the *Finish* button to start the update. **i** The update procedure may take several minutes, depending on the available bandwidth and the amount of files to be updated.

Table E.1: Updating firmware

During firmware update

- During firmware update, a log window is displayed showing all actions performed by the FCONF program.
- The log-file is stored in the same directory as the backup files.
- If an error occurs during the update procedure, the FCONF program terminates the procedure and recommends to restore the previous firmware version.

After firmware update has finished

- If the firmware update has finished, the FCONF program resets the spectrometer. The log window reads: *Resetting the spectrometer... done*.
- After a successful spectrometer initialization, the firmware version is displayed in the log window.

E.4 Restoring a previous firmware version

Restoring a previous firmware version is only possible if a firmware update has been performed first.

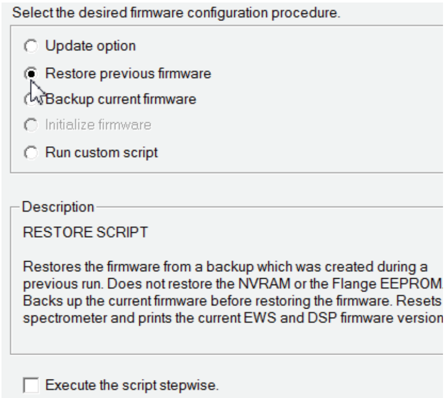
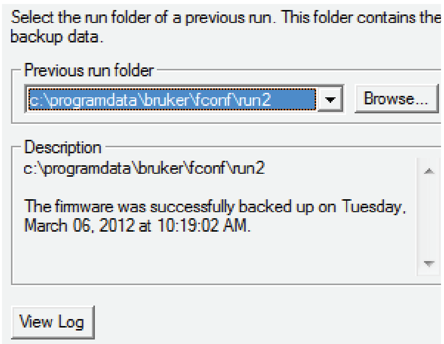
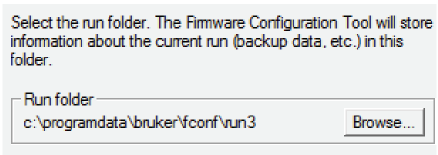
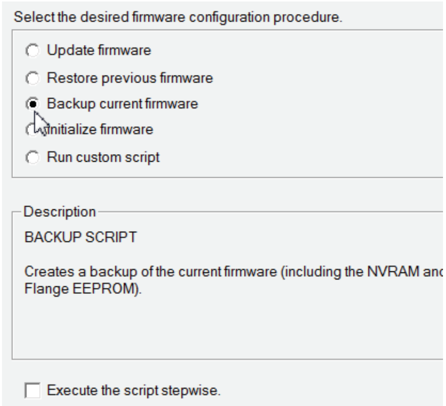
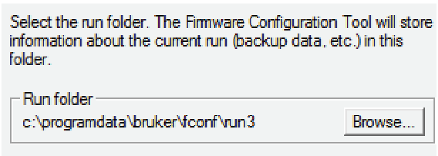
1		• Activate the *Restore previous firmware* option button. • Click the *Next* button.
2		• Select the directory containing the backup information of the last firmware version (*Previous run folder*). By default, this directory is displayed automatically. ℹ If you click the *View Log* button, a log window is displayed. The window contains detailed information about the last update including errors, warnings or other irregularities. • Click the *Next* button.
3		Specify a directory for the backup files generated. ℹ It is recommended to accept the directory set by the FCONF program. • Click the *Next* button.
4	In the next dialog, click the *Finish* button. ➢ The previous firmware version is going to be restored.	

Table E.2: Restoring previous firmware version

E.5 Backing up the current firmware version

<table>
<tr><td>1</td><td>
</td><td>• Activate the Backup current firmware option button.
• Click the Next button.</td></tr>
<tr><td>2</td><td>
</td><td>• Specify a directory for the backup files generated.

ℹ It is recommended to accept the directory set by the FCONF program.

• Click the Next button.</td></tr>
<tr><td>3</td><td colspan="2">In the next dialog, click the Finish button.
➢ The backup starts.</td></tr>
</table>

Table E.3: Backup current firmware version

F Preparation/Measurement

In general, hardly any or no sample preparation is required for FT-Raman spectroscopy. The most important feature when preparing a sample is to have an as high as possible amount of sample in the focus of the laser beam and collection lens.

Powdered samples can be packed into small aluminum or stainless steel cups. Several sample cups, a funnel, and a small aluminum plunger are supplied in the sampling kit (see appendix B). Put the sample into the cup by using the funnel, fill it up to the top, level off the sample and tighten it by a pestle.

Liquid samples can be analyzed within a liquid cell. Gaseous samples require dedicated cells such as the Raman long-path cell. Use the plain quartz cuvette, backside mirrored, from the Raman sampling kit.

F.1 Filling sample cups

NMR tubes, capillary tubes and quartz cuvettes can be used for liquid samples using the holders provided in the sampling kit. Any glass container can be used as a sample holder, however, the success of the measurement depends on the intensity of scattering caused by the sample. Some pieces of glass can fluoresce at different wavelengths and obscure the Raman peaks.

In general, the optically flat surfaces and near-IR transparency of the quartz cuvette are ideal for the measurement of liquids. The quartz itself contribute to the FT-Raman spectrum (figure F.1), but the bands can be removed by spectral subtraction.

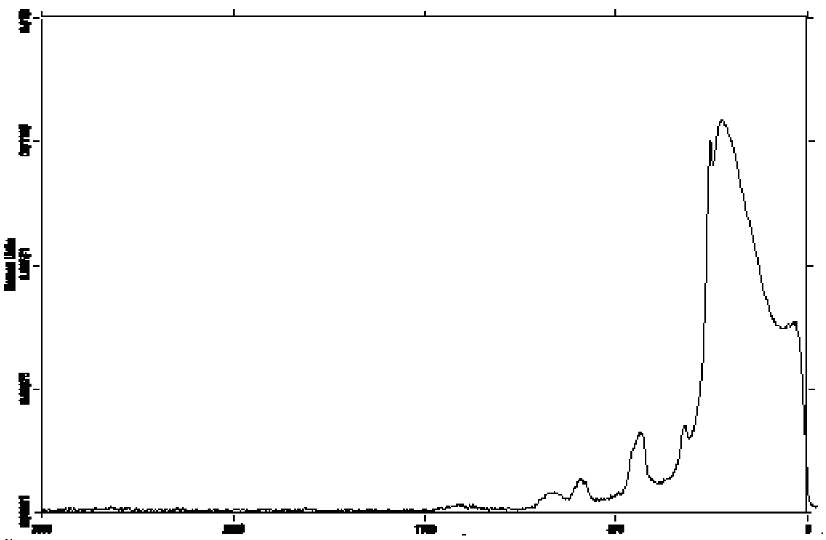


Figure F.1: FT-Raman spectrum of Quartz cuvette (empty)

F.2 Inserting sample into sample compartment

Lift the sample compartment lid. The sample stage is mounted on a QuickLock base-plate. Place the sample onto the V-grooved sample mount with the sample facing the objective lens assembly.

In case of MultiRAM, a white light (adjustment lamp) backlights the optics and can be useful when aligning the sample. The sample position is controlled by the NUM pad of the PC keyboard, e.g.:

- Left/right: by 4 and 6
- Top/down: by 8 and 2
- Back/forth: by 9 and 3

F.3 Sample position

The sample position can be optimized by using the arrow buttons on the NUM pad. Usually, the default position of *x = 100* is the best possible position for standard samples (e.g. sample cups). If, however, the sample position has to be optimized, use the *Back* or *Forth* button (chapter F.2).

Each step in either direction moves the sample by 50 µm. To reset the default position step back to the *x = 100* position, or press the button with the figure 5.

F.4 Selecting sample geometry

Most samples can be easily measured using the 180° arrangement, i.e. the laser beam hits the sample at the same side which emits the scattered radiation (back-scattering configuration). This arrangement is insensitive to slight misalignments and it is well adapted to the interferometer geometry.

F.5 Controlling laser beam size (optional)

The size of the exciting laser beam incident on the sample can be controlled by the OPUS software.

- On the *Measure* menu, select the *Advanced Measurement* command.
- Click the *Optic* tab.
- Select the *Raman Compartment defocused* channel.

i Although maximum Raman signal will be obtained when the laser is focused, defocusing the laser may be necessary if the sample heats in the laser beam.

F.6 Measuring Raman spectra

It is recommended to check the spectrometer set-up and performance using the standard samples provided in the sampling kit prior to measuring other spectra. Spectra of naphthalene and polystyrene are shown in figure F.6.

➢ Current naphthalene/polystyrene comparisons should be made using the data which is provided during spectrometer installation.

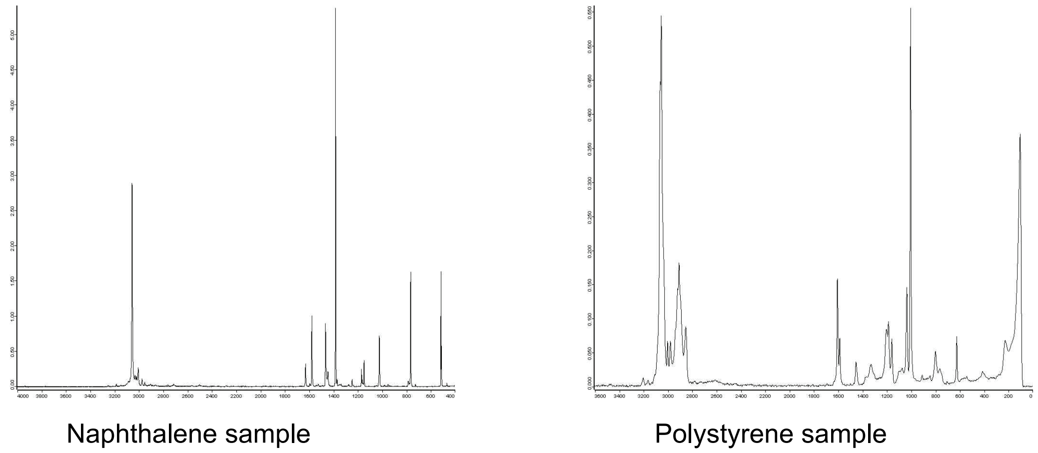


Figure F.2: Standard Raman spectra

F.6.1 Measuring procedure

Before starting measurement make sure that the spectrometer is ready to operate and that the sample is inserted into the sample compartment.

1. On the OPUS *Measure* menu, select the *Advanced Measurement* command.
2. Click the *Check Signal* tab.
   ➢ No signal will be observed until the parameters are set. Increase the laser power slowly by moving the slider displayed in the dialog, until an interferogram appears.
   ➢ Raman interferograms are quite different in shape compared to IR interferograms, and the maximum intensity of the centerburst is not always desirable. In fact, a sharp centerburst indicates the presence of broadband radiation (i.e. fluorescence or heating). To determine how the sample reacts to the laser power, check the *Spectrum* option button on the *Check Signal* tab to have the transformed Raman spectrum displayed in real time.
3. Adjust the laser power and sample position for the best spectral quality.
   ➢ Colorless and transparent solid and liquid samples can generally withstand higher power densities than colored or black samples. To avoid possible sample degradation, it is recommended to use only the power level needed to obtain satisfactory Raman intensity. The sample position is adjusted by using the NUM pad for the x direction (xyz direction is optional).

4. If the spectrum is optimized, close the *Check Signal* tab.
5. You are now ready to perform a measurement. Select the *Basic* tab and click on the *Sample Raman Spectrum* button.
   ➢ As Raman is an emission technique, no background spectrum is required.

F.6.2 Spectrum interferences

There are two effects which may cause difficulties when measuring a Raman spectrum: fluorescence and heating. Fluorescence is displayed as a broad band or as a large baseline offset throughout the spectrum, see figure F.3.

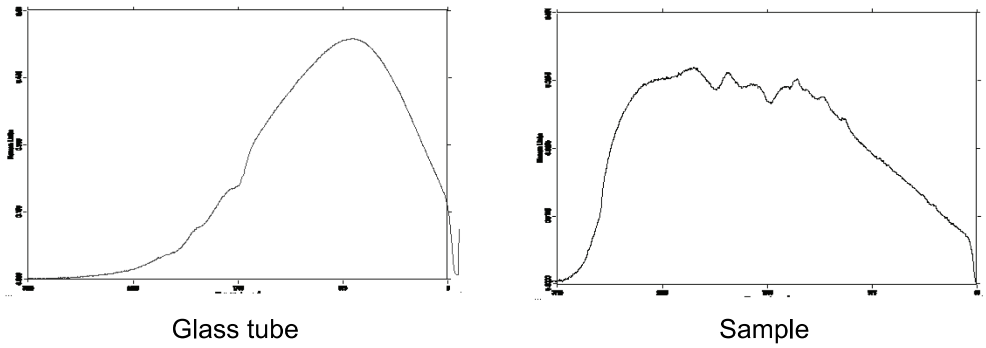


Figure F.3: FT-Raman spectra showing fluorescence

The large number of photons created by this effect may even overload the detector or at least obscure the Raman signal.

In case of heating, the spectrum shows a broad tail of the black body radiation curve which increases at higher Raman shift, see figure F.4.

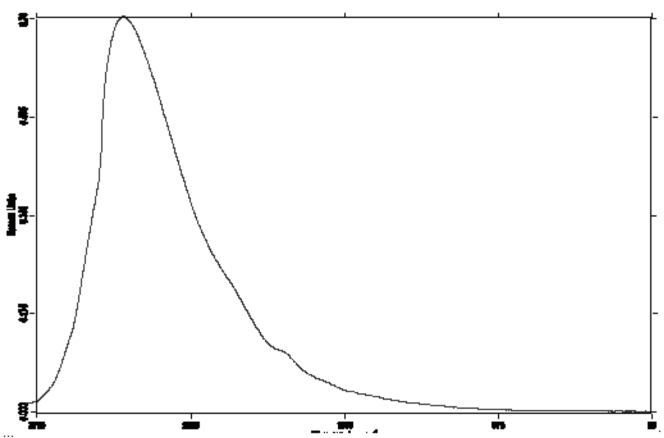


Figure F.4: FT-Raman spectrum showing heated sample

Heating effects can be reduced by any of the following:

- Using an unfocused laser beam
- Reducing laser power
- Cooling the sample
- Dispersing the sample in a matrix such as KBr powder
- Spinning the sample in the laser beam

Fluorescence can sometimes be reduced by purifying the sample.

Another interference which may be observed is the presence of water vapor in the spectrometer. The actual effect is absorption of background NIR radiation by the water vapor. Figure F.5 shows the position of these overtone bands of water.

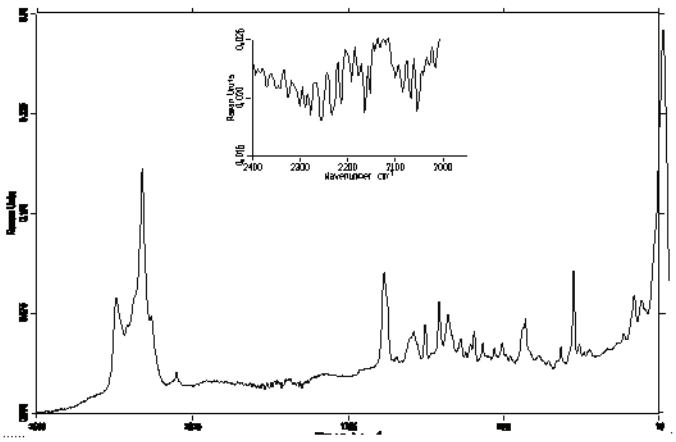


Figure F.5: FT-Raman spectrum showing water vapor absorption of background radiation

Excessive water vapor can be removed by continuously purging the instrument.

F.7 Correcting Raman spectra

Raman is an emission technique and a background measurement is not required to generate a spectrum. However, the intensities of the bands in the spectrum may depend on the individual spectrometer components.

To correct the band intensities, it is necessary to generate an instrument response curve. You do not need to correct every Raman spectrum, especially if you use the spectrum for qualitative information only. However, if you want to compare the spectrum with an existing data base (either FT-Raman or conventional Raman) or perform quantitative analysis, the spectra should be corrected for the instrument response.

The OPUS software includes a Raman correction option in the OPUS *Manipulate* menu. For further details, see the OPUS Reference Manual. To be able to use this function it is necessary to collect a reference lamp emission spectrum. The light source to generate the emission spectrum is mounted in the sample compartment on the right side.

F.7.1 Setting up reference lamp

A reflector set is supplied with the Raman system as part of the standard sampling kit.

1. On the OPUS *Measure* menu, select the *Advanced Measurement* command to switch on the reference lamp.
2. Click the *Optics* tab and select *Reference lamp* from the *Source Setting* drop-down list.
3. Insert the reflector into the sample holder and adjust the position of the reflector. Make sure that the light hits the second reflector.
4. Before collecting the tungsten lamp spectrum click the *Check Signal* tab. Make sure that the signal in the interferogram is not above an ADC value of 32,768 counts. Note the current value for future reference.

F.7.2 Performing Raman correction

It is essential that the lamp spectrum to be measured uses the same parameters as the sample spectra to be corrected. It is advisable that the S/N of the lamp spectrum is better than that of the sample spectra, and thus avoiding the S/N of the latter to be degraded by correction. It is therefore recommended to measure at least 100 scans.

Measure the spectrum and store it by an easily recognizable file name. You can now use the Raman correction. The temperature of the filament should have the value of 2300 K.

G Safety data sheets

Safety Data Sheet

According to EC Directive 91/155/EEC

Date of issue: 20.07.2003 Supersedes edition of 05.10.2001

1. Identification of the substance/preparation and of the company/undertaking

Identification of the product

Catalogue No.: 820846

Product name: Naphthalene for synthesis

Use of the substance/preparation

Chemical for synthesis

Company/undertaking identification

Company: Merck Schuchardt OHG * 85662 Hohenbrunn * Germany * Tel: +49 8102/802-0

Emergency telephone No.: Please contact the regional Merck representation in your country.

2. Composition/information on ingredients

CAS-No.:	91-20-3	EC-Index-No.:	601-052-00-2
M:	128.16 g/mol	EC-No.:	202-049-5
Formula Hill:	$C_{10}H_8$		

3. Hazards identification

Harmful if swallowed. Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

4. First aid measures

After inhalation: fresh air. Consult doctor if feeling unwell.
After skin contact: wash off with plenty of water. Remove contaminated clothing.
After eye contact: rinse out with plenty of water. If pain persists, call in ophtalmologist.
After swallowing: make victim drink plenty of water, induce vomiting. call in physician if feeling unwell.

5. Fire-fighting measures

Suitable extinguishing media:
powder, foam, water.

Special risks:
Combustible. Development of hazardous combustion gases or vapours possible in the event of fire.

Special protective equipment for fire fighting:
Do not stay in dangerous zone without suitable chemical protection clothing and self-contained breathing apparatus.

Other information:
Prevent fire-fighting water from entering surface water or groundwater. Contain escaping vapours with water.

The Safety Data Sheets for catalog items are also available at www.chemdat.de

Page 1 of 5

Merck Safety Data Sheet According to EC Directive 91/155/EEC

Catalogue No.: 820846
Product name: Naphthalene for synthesis

6. Accidental release measures

Person-related precautionary measures:
Avoid substance contact. Avoid generation of dusts; do not inhale dusts. Ensure supply of fresh air in enclosed rooms.

Environmental-protection measures:
Do not allow to enter sewerage system.

Procedures for cleaning / absorption:
Take up dry. Forward for disposal. Clean up affected area.

7. Handling and storage

Handling:

No further requirements.

Storage:

Tightly closed. Dry. In a well-ventilated place. At +15°C to +25°C.

8. Exposure controls/personal protection

Personal protective equipment:

Protective clothing should be selected specifically for the working place, depending on concentration and quantity of the hazardous substances handled. The resistance of the protective clothing to chemicals should be ascertained with the respective supplier.

Respiratory protection: required when dusts are generated.

Eye protection: required

Hand protection: In full contact:

Glove material: nitrile rubber
Layer thickness: 0.11 mm
Breakthrough time: > 480 Min.

In splash contact:

Glove material: nitrile rubber
Layer thickness: 0.11 mm
Breakthrough time: > 480 Min.

The protective gloves to be used must comply with the specifications of EC directive 89/686/EEC and the resultant standard EN374, for example KCL 740 Dermatril® (full contact), 740 Dermatril® (splash contact). The breakthrough times stated above were determined by KCL in laboratory tests acc. to EN374 with samples of the recommended glove types.
This recommendation applies only to the product stated in the safety data sheet and supplied by us as well as to the purpose specified by us. When dissolving in or mixing with other substances and under conditions deviating from those stated in EN374 please contact the supplier of CE-approved gloves (e.g. KCL GmbH, D-36124 Eichenzell, Internet: www.kcl.de).

Industrial hygiene:
Change contaminated clothing. Application of skin- protective barrier cream recommended. Wash hands after working with substance.

Merck Safety Data Sheet According to EC Directive 91/155/EEC

Catalogue No.: 820846
Product name: Naphthalene for synthesis

9. Physical and chemical properties

Form:		solid			
Colour:		white			
Odour:		characteristic			
pH value			not available		
Melting point			79-82	°C	
Boiling point			218	°C	
Ignition temperature			540	°C	
Flash point			80	°C	c.c.
Explosion limits	lower		0.9	Vol%	
	upper		5.9	Vol%	
Vapour pressure		(20 °C)	0.066	hPa	
Density		(20 °C)	1.15	g/cm^3	
Bulk density			600	kg/m^3	
Solubility in					
water		(20 °C)	0.3	g/l	
ethanol		(20 °C)	77	g/l	
Bioconcentration factor			> 200		

10. Stability and reactivity

Conditions to be avoided

Strong heating.

Substances to be avoided

Violent reactions possible with: oxidizing agent, nitrogen oxides, chromium(VI) oxide.

Hazardous decomposition products

no information available

Further information

dust explosion possible.
Explosible with air in a vaporous/gaseous state when heated.

11. Toxicological information

Acute toxicity

LC_{50} (inhalation, rat): >100 mg/l /4 h.
LD_{50} (dermal, rat): >2500 mg/kg.
LD_{50} (oral, rat): >2000 mg/kg.

Specific symptoms in animal studies:
Eye irritation test (rabbit): Slight irritations.
Skin irritation test (rabbit): Slight irritations.

Subacute to chronic toxicity

Not mutagenic in the acute test.

The Safety Data Sheets for catalog items are also available at www.chemdat.de **Page 3 of 5**

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Further toxicological information

After inhalation of dust: Irritation symptoms in the respiratory tract.
After skin contact: dermatitis. Danger of skin absorption.
After eye contact: Slight irritations. Risk of corneal clouding.
Systemic effects: headache, gastrointestinal complaints, tremor, spasms, respiratory paralysis, changes in the blood picture.

Further data

The product should be handled with the care usual when dealing with chemicals.

12. Ecological information

Biologic degradation:
Hardly eliminable.

Behavior in environmental compartments:
BCF: >200.

Ecotoxic effects:
Biological effects:
Highly toxic for aquatic organisms. May cause long-term adverse effects in the aquatic environment.
Hazard for drinking water supplies.

aquatic organisms LC_{50}: 1 mg/l /96 h.
fish LC_{50}: 0.12 mg/l /96 h.
Algeal toxicity: algae EC_{50}: 33 mg/l /24 h.

Further ecologic data:
Degradability:
BOD 0 % from TOD /5 d; COD 22 % from TOD, TOD: 2.99 g/g.

Do not allow to enter waters, waste water, or soil!

13. Disposal considerations

Product:

Chemicals must be disposed of in compliance with the respective national regulations. Under www.retrologistik.de you will find country- and substance-specific information as well as contact partners.

Packaging:

Merck product packaging must be disposed of in compliance with the country-specific regulations or must be passed to a packaging return system. Under www.retrologistik.de you will find special information on the respective national conditions as well as contact partners.

The Safety Data Sheets for catalog items are also available at www.chemdat.de

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Merck Safety Data Sheet According to EC Directive 91/155/EEC

Catalogue No.: 820846
Product name: Naphthalene for synthesis

14. Transport information

Land transport ADR, RID
UN 1334 NAPHTHALEN, RAFFINIERT, 4.1, III

Transport by river ADN, ADNR not tested

Transport by sea IMDG, GGVSee
UN 1334 NAPHTHALENE, REFINED, 4.1, III
Ems 4.1-0

Transport by air CAO, PAX
NAPHTHALENE, REFINED, 4.1, UN 1334, III

The transport regulations are cited according to international regulations and in the form applicable in Germany (GGVSE). Possible national deviations in other countries are not considered.

15. Regulatory information

Labelling according to EC Directives

Symbol:	Xn	Harmful
	N	Dangerous for the environment
R-phrases:	22-50/53	Harmful if swallowed. Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
S-phrases:	36/37-60-61	Wear suitable protective clothing and gloves. This material and its container must be disposed of as hazardous waste. Avoid release to the environment. Refer to special instructions/Safety data sheets.
EC-No.:	202-049-5	EC label

Reduced labelling (1999/45/EC,Art.10,4)

Symbol:	Xn	Harmful
	N	Dangerous for the environment
R-phrases:	22	Harmful if swallowed.
S-phrases:	---	

16. Other information

Reason for alteration

General update.

Regional representation:

This information is given on the authorised Safety Data Sheet for your country.

The information contained herein is based on the present state of our knowledge. It characterizes the product with regard to the appropriate safety precautions. It does not represent a guarantee of the properties of the product.

The Safety Data Sheets for catalog items are also available at www.chemdat.de

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H Glossary

Alignment	The adjustment of optical components, e.g. mirrors and lenses, to bring all their optical axes in line to maximize spectrometer performance.
Beamsplitter	The beamsplitter splits the incident beam into two separate ligth waves. Generally, the beamslitter is a half-mirrored substrate that reflects and transmits approximately equal portions of the incident radiation.
Cross-over cable	The cross-over cable includes a RJ45 plug on each cable end. In one plug, however, the pairs leading the signal are swapped (crossed). That means, one plug swaps the transmission data with the received data to enable data exchange when one terminal device is directly connected to another. If the transmission and received data were not swapped at one cable end, a connection could not be accomplished.
Detector	A detector converts incoming light into an electrical signal.
Ethernet	Ethernet is the most widely installed Local Area Network (LAN). A LAN is a network of interconnected workstations sharing the resources of a single processor or server within a relatively small geographic area (i.e. an office building). Ethernet is a set of hardware and signaling standards used for LANs. The most commonly installed systems are 10/100/1000 BaseT.
Fourier Transform	Fourier Transform (FR) spectroscopy is a mathematical transformation method used to convert an interferogram into an infrared spectrum. Essentially, Fourier Transform decomposes or separates a waveform or function into sinusoids of different frequencies. All these different frequencies together sum to the original waveform. Fourier Transform identifies or distinguishes the different frequency sinusoids and their respective amplitudes.

Frequency

Frequency is the number of occurrences of a repeating event per unit time. In equations, frequency is denoted by the Greek letter ν. The following equation applies to the frequency of a wave ν: $\nu = \frac{c}{\lambda}$, with *c* being the phase velocity of the wave in the respective medium, and λ (lambda) being the wavelength. The wavelength is no timely but local parameter.

Any kind of time-restricted vibration process, even in the form of a sinusoid, always represents an overlapping of several frequencies.

FT-Raman spectroscopy	Until the advent of FT-Raman conventional Raman had been restricted to the research technique. In conventional Raman spectroscopy where visible lasers are commonly used to excite the Raman effect, nearly 90% of the samples contain impurities which produce strongly interfering fluorescence. The intensity of this fluorescence is often stronger than the scattered Raman signal, and make any useful spectroscopic information impossible. It could be made evident that when using an Nd:YAG laser to excite the Raman effect, the number of samples which fluoresced could be greatly reduced. This is due to the fact that there is a reduced amount of electronic transition at the Nd:YAG laser wavelength of 1064 nm, which means low photon energies. Besides, the advantage is that these low photon energies, sample heating and subsequent photochemical degradation becomes less likely. Using an excitation of 785 nm will increase the probability of fluorescence. In some cases, however, i.e., for the analysis of silicon samples, the excitation of 785 nm is recommended as an alternative to NIR excitation. FT-Raman spectroscopy in the near-infrared presents some interesting instrumental challenges. Raman lines have an intensity which is proportional to the 4th power of the exciting frequency. Comparing excitation with a conventional argon ion laser at 488 nm to that of the Nd:YAG laser line at 1.06 µm indicates that the anticipated decrease in sensitivity is at least a factor of 22.6 with the Nd:YAG laser. The noise equivalent power (NEP) of near-infrared detectors is usually several orders of magnitude higher than that of the photomultiplier tubes used in conventional Raman. In FT-Raman, there is a multiplex disadvantage, since the statistical noise of the exciting radiation scattered onto the detector is transformed to noise at all frequencies in the Raman spectrum. The power of the exciting Nd:YAG laser line can be increased as a small number of substances absorb at this frequency. Spectrometer throughput is high since the optical conductance of the interferometer used in FT-Raman is at least one order of magnitude greater than that of a dispersive spectrometer. Increases in sensitivity result from the multiplex gain of Fourier spectroscopy. Multiplexing does not reduce the shot noise of the signal itself but does decrease noise caused by the detector. The additional noise caused by the solid state near-infrared detector is compensated by the multiplex gain. Using proprietary low noise detectors further decrease the noise. To avoid the possible multiplex disadvantage of FT-Raman, an efficient mechanism for rejecting scattered laser line is incorporated in the spectrometer.

Gateway address	A gateway is a kind of connecting point between different networks, which controls data traffic of the respective network. A gateway address is the address of a particular gateway within a network.
Interferogram	The interferogram is a plot of detector signal as a function of optical path length difference. Spectrometers are equipped with a broadband light source, which yields a continuous infinite number of wavelengths. The interferogram is the continuous sum, i.e. the integral of all the interference patterns produced by each wavelength. This results in the intensity curve as function of the optical retardation. At the zero path difference of the interferometer (Δ x=0) all wavelengths undergo constructive interference and sum to a maximum signal. As the optical retardation increases different wavelengths undergo constructive and destructive interference at different points, and the intensity therefore changes with retardation. For a broadband source, however, all the interference patterns will never be simultaneously in phase except at the point of zero path difference, and the maximum signal occurs only at this point. This maximum in the signal is referred to as the centerburst. Dispersive elements detected in the optical path can cause chirping in the centerburst.
Interferometer	An interferometer detects interferences, that means overlappings of light waves. Inside the interferometer a light beam is splitted into two light waves (beams) by the beam splitter. These two light waves pass through optical paths of different lengths, are reflected by additional mirros, and finally recombined. If you change the optical path of one of the two light waves, e.g. by moving one mirror, the phases of the two light waves displace against each other. When recombining the light waves, interferences occur. The result is an interference pattern (stripes or rings) which has been written by the light waves. This pattern is determined by the difference of the optical path lengths which the single light waves have passed before being recombined.
IP address	An IP address is the network address of a workstation or network. IP addresses consist of 4 number fields separated by dots. Each number field represents 1 byte. Values can be between 0 and 255. The numbers on the left of the string define the network, the numbers on the right define the individual workstation or Network Interface Card (NIC).
Laser	The laser is a coherent source of monochromatic radiation. It is an essential part of the interferometer system. Due to laser light interference the position of the movable mirror, and the data sampling positions are determined.

Micrometer (µm)	Micrometer is a length unit of 10^{-6} meter, which is equal to a thousandth of a millimeter.
Optical path	The optical path is the distance of the light passing through the spectrometer. The distance between two points in the light beam is calculated in longitudinal direction, and multiplied by the refraction index of the medium.
OQ test	The OQ (Operational Qualification) is a test category used to validate the spectrometer. This test checks the current instrument performance and compares it to the one specified. The OQ test consists of several single tests and is performed within a defined time interval. Generally, the OQ test protocol runs during final testing before an instrument is delivered to the customer, after each major repair, exchange of optical components which may influence the instrument performance, and on a regular yearly or semi-yearly basis after maintenance.
PQ test	The PQ (Performance Qualification) is a test category used to validate the spectrometer. The test evaluates the performance and proper function of the spectrometer. The PQ test consists of several single tests and is performed within a defined time interval. Generally, the test is intended to be performed once a day.
Raman effect	Monochromatic light is scattered when hitting molecules. The Indian physicist C. V. Raman spent a long time in the study of this scattered light. In 1928 he observed two low intensity spectral lines corresponding to the incident monochromatic light. It was clear that though the incident light was monochromatic, the scattered light due to it, was not monochromatic. The Raman Effect confirmed that light can be interpreted as particles known as photons. The energy and thus the frequency and wavelength of scattered light is changed as the light either imparts rotational or vibrational energy to the scattering molecules or removes energy. The line spectrum of the scattered light will have one prominent line corresponding to the original wavelength of the incident radiation, plus additional lines to each side of it corresponding to the shorter or longer wavelengths of the altered portion of the light.

Raman spectroscopy	Raman spectroscopy is based on the Raman effect, i.e. the measurement of the wavelength and intensity of inelastically scattered light from molecules or crystal lattices. The Raman scattered light occurs at wavelengths that are shifted from the incident light by the energies of molecular vibrations. Due to the interaction between matter and monochromatic light, the vibrational energy changes. This is in contrast to infrared spectroscopy, where the vibrational energy of molecules changes the absorption of infrared radiation. However, Raman and IR spectra provide complementary molecular structural information. Typical applications of Raman spectroscopy are in structure determination, multi-component qualitative analysis, and quantitative analysis.
Relative humidity	Relative humidity is the amount of water vapor in the air, which can be between 0 and 100%.
Resolution	Resolution in FT-IR is determined by the maximum optical path difference reached in the measurement of an interferogram. The spectral resolution corresponds to the minimum possible spectral distance between 2 adjacent spectral lines which can be resolved by the spectrometer. It is produced by the instrumental spectral line shape and the line width of the sample's absorption. The instrumental line shape is reciprocally related to the travel distance of the movable mirror in the interferometer, and also influenced by the apodization function and divergence in the interferometer. The higher the spectral resolution (smaller values), the higher the noise in the spectrum.
Sample	A sample is a special kind of substance which is put into the spectrometer sample position and measured.
Signal-to-noise ratio	The signal-to-noise ratio describes the quality of a wanted signal which has been superimposed by noise. It outlines the ratio between the average performance of a wanted signal emitted by a signal source, and the average performance of noise.
Spectrometer	Spectrometer derives from the Latin word *specere* meaning image, and the Greek word *metron* meaning to measure. A spectrometer uses some sort of mechanical or electrical detection device to obtain the infrared spectrum of a sample. It contains a source of infrared radiation, a sample compartment to allow the radiation to interact with a sample, a detector for radiation, and units to determine and display the intensity of radiation.

Spectrum	A spectrum is an image of radiation energy dispersed into its wavelength constituents or a two-dimensional plot of radiation energy, or radiation energy ratio versus wavelength. It includes a set of absorption, reflection or transmission values which have been measured by an IR spectrometer based on defined wavelengths. The features in an infrared spectrum correlate with the presence of functional groups of molecules of a sample.
Subnet mask	The subnet mask is a network mask used to partition network addresses for efficiency and security. Subnet masks work by 'masking' less significant address bits on all workstations in the sub-network.
Validation	In general, validation evidently documents that, by the use of specific laboratory investigation methods, a process or system (spectrometer) meets the previously defined requirements (acceptance criteria) in reproducible manner and for its intented analytical use. During spectroscopic validation the x-axis (frequency) and y-axis (transmission, reflection) are verified by transmission or reflectance standards which may be included in the internal spectrometer validation unit. Validation can be performed at individual time intervals by the application software.
Wavelength	The wavelength λ is the distance between two maxima on a sinusoidal wave, i.e. the distance traversed by one period of an electromagnetic wave. The wavelength depends on the refractive index of the medium which the electromagnetic wave travels through.
Wavenumber	The wavenumber $\tilde{\nu}$ is the reciprocal of the wavelength λ. The wavenumber is defined as $\tilde{\nu} = \frac{1}{\lambda_0}$ with the unit of cm^{-1}, that means the number of waves per each centimeter.

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EC-DECLARATION OF CONFORMITY

The undersigned, representing the following manufacturer

Manufacturer: BRUKER OPTIK GMBH
Address: Rudolf-Plank-Straße 27, 76275 Ettlingen, Germany

herewith declares that the product

Product identification: **MultiRAM**

is in conformity with the provisions of the following EC directive(s)
(including all applicable amendments)

Ref. - no.	Title
2004/108/EC	Directive of the European Parliament and of the Council of 15 December 2004 (Electromagnetic Interference Directive)
2006/95/EC	Directive of the European Parliament and of the Council of 12 December 2006 (Low Voltage Directive)

and that the standards and / or technical specifications referenced overleaf have been applied.

Ettlingen
(Place)

May 14th, 2013
(Date)

(Signature)

Dr. Arno Simon, Development Manager
(Name and function of the signatory empowered to bind the manufacturer or his authorized representative)

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References of standards and/or technical specifications applied for this declaration of conformity, or parts thereof :

Harmonized standards:

No.	Issue	Title
EN 61326-1:2006	October 2006	Electrical equipment for measurement, control and laboratory use – EMC requirements
EN 61000-3-2:2006 +A1:2009+A2:2009	March 2010	Electromagnetic compatibility Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16A)
EN 61000-3-3:2008	June 2009	Electromagnetic compatibility; Part 3-3: Limits - Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current ≤ 16A
EN 61010-1:2010 (3rd Edition)	July 2011	Safety requirements for electrical equipment for measurement, control and laboratory use Part 1: General requirements
EN 60825-1:2007	May 2008	Safety of laser products Part 1: Equipment classification and requirements

Other standards and/or technical specifications:

No.	Issue	Title	Parts (1)
EN ISO 13849-1:2008		Safety of machinery – Safety-related parts of control systems – Part 1 : General principles for design	1

Other technical solutions, the details of which are included in the technical documentation or the technical construction file:

....

Other references or information required by the applicable EC directive(s):

....

(1) Where appropriate, the applicable parts or clauses of the standard or the technical specification shall be referenced.

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