VERTEX 80v

User Manual

1003246

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This manual is the original documentation for the FT-IR spectrometer VERTEX 80v.

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1 Safety

1.1 General safety information

Read carefully all instructions and safety notes in this manual before installing and putting the spectrometer into operation. Keep this manual for future reference available at any time.

Always observe the instructions and safety notes given in this manual. Failure to do so can lead to personal injuries and/or property damage. Non-observance of the instructions and safety notes will violate the intended use of the spectrometer. (See section 1.5.)

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 trouble-free operation of the spectrometer is ensured only if all components of the analysis system are installed and operated as well as maintained and repaired according to the procedures described in this manual and in compliance with all relevant safety standards and regulation.

The spectrometer should be operated only by authorized personnel which is trained in operating the spectrometer and which is familiar with the relevant safety instructions and laser safety regulations.

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

The spectrometer complies with the IEC/EN 61010-1 safety regulations.

1.2 Classification of the safety notes

Depending on the degree of hazard, important safety notes are classified in this manual by signal words as follows:

DANGER

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

WARNING

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

CAUTION

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

NOTE

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

1.3 Overview of possible types of hazard

1.3.1 Possible hazards during installation and operation

Hazards that can possibly occur during installing, operating and repairing the spectrometer are indicated by the appropriate warning labels on the spectrometer. The following warning labels indicate different dangerous situations which may be caused by an improper use of the analysis system:

Warning symbol	Definition
	**General hazard:** This warning symbol indicates a general hazard. The label is located near the danger spot in question. Observe the safety instructions and follow the precautions described to avoid personal injury and/or property damage.
	**Laser radiation:** This warning symbol indicates the existence of laser radiation. The label is located near the aperture at which hazardous laser radiation exits the instrument. Do not 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.
	**Electrical shock:** This warning symbol indicates an electrical hazard. The label is located near live parts or on housings behind which are live parts that represent an accidental contact hazard. Do not touch these parts. Before removing the corresponding housing and beginning any maintenance or repair work, first turn off the main power switch and unplug the main power cable. Ensure that all live parts do not come into contact with a conductive substance or liquid. Non-observance of these safety instructions can cause severe personal injury and/or property damage.
	**Hot surface:** This warning symbol refers to components and surfaces which can become very hot during the spectrometer operation. Do not touch these components and surfaces. Risk of skin burn! Be careful when operating near hot components and/or surfaces.
	**Danger of frostbite:** This warning symbol indicates cryogenic liquids (e.g. liquid nitrogen) required to operate the spectrometer (e.g. cooling the 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.

Important: All warning labels on the spectrometer must always be kept legible. Immediately replace a worn or damaged label!

1.3.2 Possible hazardous sample materials

There can also be hazards caused by the sample material. Depending on the type of hazardous substances you work with, you have to observe specific substance-relevant safety instructions. Affix the corresponding warning label at the appropriate place at the spectrometer. The label must be well legible and permanently discernible. The following list contains some examples of hazardous substances:

Symbol	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*.
	**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.

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.

1.4 Laser safety

The interferometer is equipped with a HeNe laser. This laser emits red light with a wavelength of 632.8nm. The rated power output is 5mW. According to EN 60825-1:2007, the laser is laser class 3R product.

Due to constructional measures, the spectrometer is classified as a laser class 2 product, i.e. the intensity of accessible laser radiation is reduced.

During all exchange, repair and maintenance works (e.g. manual beamsplitter exchange, replacement of a defective MIR source) which require the opening of the interferometer compartment, observe the following safety instructions regarding laser class 2.

⚠ WARNING

Eye injury because of exposure to laser radiation of laser class 2

Non-observance of the following safety instruction could result in injury.

➢ Do not stare into the laser beam! An exposure time > 0.25 sec. will cause eye injury.

1.5 Intended use

The spectrometer is designed for FT-IR spectroscopic measurements under vacuum conditions. It is suited for all kinds of solid and liquid and gaseous samples which absorb infrared light (radiation energy).

The spectrometer is approved for the use in a laboratory under the environmental conditions specified in appendix A.5.

The intended use includes also the compliance with the relevant standards and regulations, especially:

- regional or national safety regulations
- regional or national accident prevention regulations
- generally recognized technical regulations

The intended use also includes the strict observance of all instructions given in this manual, namely:

- safety instructions
- installation instructions,
- operation instructions
- repair and maintenance instructions

Use only components and accessories supplied by Bruker. For components and accessories made by other manufacturers and used in conjunction with the spectrometer, Bruker Optik GmbH does not assume any liability for safe operation and proper functioning.

⚠ WARNING

Health hazard because of unintended use of the spectrometer

Non-observance of the following safety instruction could result in serious injury (possibly irreversible skin and/or eye injuries).

➢ Do not take any action that violates the intended use. The operational safety of the spectrometer is ensured only if it is used as intended.

1.6 Service contact data

In case you have questions about safety, installation and/or operation as well as repair and maintenance of the spectrometer or you need technical assistance in case of a hardware and/or software problem, you can contact the Bruker service as follows:

- 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.brukeroptics.com

2 General

2.1 Technical features

The spectrometer is equipped with a number of features such as AAR (Automatic Accessory Recognition) ACR (Automatic Component Recognition) and Performance-Guard that facilitate performing spectroscopic measurements and ensure reliable measurement results. The function AAR identifies automatically the accessory installed in the sample compartment, performs several tests and loads automatically the corresponding experiment file including the pre-defined measurement parameters. The function ACR recognizes automatically the currently installed optical components like source, detector and beamsplitter. These components are electronically coded so that the spectrometer firmware can recognize them. This information is passed on to the application software OPUS. The purpose of ACR is to enable the user to select the right optics parameters in OPUS. In addition, the spectrometer components are monitored permanently to ensure that they operate within the specification range. This feature is called Performance Guard. Its purpose is to facilitate fault diagnostics and maintenance.

The data acquisition is based on a free running delta-sigma, dual-channel A/D converter with 24-bit dynamic range. The A/D converter is integrated into the detector preamplifier electronics. The DigiTect technology ensures a signal transmission free from interferences and guarantees the highest signal-to-noise ratio.

The spectrometer can be controlled by any data system (PC workstation, notebook etc.) on which the operating system Microsoft Windows and the spectroscopic software OPUS is installed. The Ethernet connection provides the possibility to control the spectrometer also via your intranet or the internet.

The standard spectrometer configuration is equipped for data acquisition in the mid IR region. Optionally, the spectrometer can be equipped with different optical components to cover the whole spectral range - starting in the far infrared or THz region at 5cm^{-1} up to the ultraviolet region at 50,000cm^{-1}. Due to the pre-aligned optical components and the actively aligned UltraScan interferometer, the spectral range can be changed easily. If you work with the advanced spectrometer configuration (i.e. two detector positions and two source positions are available inside the spectrometer) you can select them using the software. Removable vacuum-tight covers provide access to the detector and beamsplitter if you want to exchange these components.

Diagnostic routines help to maintain optimum instrument status and performance. The internal validation unit (IUV) is located inside the spectrometer. It contains standards (test samples) used for the validation and testing of the instrument.

2.2 Evacuation ability

The evacuable spectrometer allows measurements under vacuum conditions, i.e. unwanted atmospheric interferents (e.g. water vapor or carbon dioxide) are eliminated nearly completely from the spectrometer interior. Evacuating the spectrometer is more efficient than purging it or using desiccant cartridges. The result of an optimal measurement under vacuum conditions is an IR spectrum in which no H_2O or CO_2 vapor absorptions mask weak spectral features.

The spectrometer design enables a separate evacuation of the spectrometer compartments, i.e. either the complete spectrometer interior (sample compartment plus the optical bench) or only the optical bench can be evacuated. Vacuum shutters (so called flaps), which can be equipped with optical windows, allow a ventilation of only the sample compartment in order to preserve the vacuum in the rest of the optics compartment during a sample change or an accessory installation. Evacuating and venting the sample compartment and/or optical bench are computer-controlled. Moreover, the spectrometer is equipped with two pressure sensors providing for the display of the current pressure inside the spectrometer optics and/or sample compartment.

The spectrometer is supplied with an efficient vacuum pump that can evacuate the spectrometer optics within a few minutes. The oil-free vacuum pump prevents the spectrometer optics from being contaminated by hydrocarbons.

2.3 Spectrometer validation

The spectrometer and the spectroscopy software OPUS are designed for validating the spectrometer to ensure that the spectrometer operates within the specifications and delivers reliable measurement results. For this purpose, the spectrometer is equipped with a computer-controlled internal validation unit (IVU) as a standard feature. The IVU is a wheel equipped with different filters. Depending on which test protocol (OQ[1] or PQ[2]) is running, the corresponding filter is moved automatically in the beam path. Validation intervals and test protocols (OQ and PQ) are defined by the user using OVP[3]. For detailed information about OVP and spectrometer validation, refer to the OPUS Reference Manual.

2.4 Possible instrumental set-ups

The spectrometer has five IR beam outlet ports (on the right, front and left side) and two IR beam inlet ports (on the right and rear side) allowing the connection of a multitude of optional accessories and/or components like:

- TGA - FT-IR coupling
- PMA 50 (Polarization Modulation Accessory for VCD and PM-IRRAS)
- HYPERION 1000/2000 IR microscope and HYPERION 3000 imaging microscope with FPA detector (Focal Plane Array detector system)
- IMAC module (Imaging Accessory with FPA detector)
- HTS-XT module (High Throughput Screening Extension)
- Fiber optic coupling module with MIR or NIR fiber probes for solid and liquid samples
- FT Raman module (e.g. RAM II)
- FIR bolometer
- External, water-cooled source

Depending on the requirements, the R&D applications impose on the analysis system, a large number of different instrumental set-ups is possible.

1. OQ - Operational Qualification
2. PQ - Performance Qualification
3. OVP - OPUS Validation Program

VERTEX 80v plus HYPERION plus PMA50	VERTEX 80v plus HYPERION plus RAM II plus cryostat
	
VERTEX 80v plus cryostat for photoluminescence	**VERTEX 80v plus bolometer plus cryostat**
	

Figure 2.1: Examples of possible instrumental set-ups

As figure 2.1 illustrates, there are many possibilities to connect several accessories and/ or components simultaneously to the spectrometer.

An example for a very comprehensive instrumental set-up is the following: a water-cooled Hg-arc source at the rear side, the RAM II FT-Raman module at the right side, a fibre optics coupling at the right front side, the HYPERION IR microscope at the left side and a bolometer detector at the front side.

3 Installation

3.1 General information

Installation and initial start-up of the spectrometer are done by Bruker service technicians. The operating company has to provide an installation site that meets the site requirements described in section 3.5. (See also the technical document *Installation Requirements for VERTEX 80v* provided by Bruker Optik GmbH in advance.)

The installation of the spectrometer includes the following works:

- connecting the spectrometer to the power supply
- connecting the spectrometer to the vacuum pump
- connecting the spectrometer to a compressed-air line
- connecting the spectrometer to the purge gas supply line
- connecting the spectrometer to a computer

For detailed information about how to install the computer, refer to the computer manual.

3.2 Delivery scope

The delivered items are divided into standard components and optional components. So the actual delivery scope depends on the customer's order.

Standard components:	The standard delivery scope includes the following items: • VERTEX 80v (including the user manual) • Power cord • Compressed air hose (OD: 6mm, length: approx. 5m) • PC compatible data system (if desired, the PC can also be provided by the customer) • Data cable (Cat5, crossover cable for 10Base-T Ethernet standard) • Tool kit (slot-head screw driver, cross-head screwdriver and hex keys of several sizes, sample preparation tools, 3x spare fuses, IR sensor card, metallic cap) • OPUS software, basic IR package (including the OPUS Reference Manual) For installing and operating the vacuum pump, the following items are included: • Vacuum pump (including the user manual) • Vibration absorber • 2x flexible metal hoses • 4x hose clamps • 4x sealing rings
Optional components:	In addition, the delivery scope can include also following optional components: • Optional spectrometer components (e.g. optional detectors, sources and/or beamsplitter) • Optional accessories • Optional OPUS software packages (QUANT, IDENT, etc.) including the corresponding manuals • Purge option (S316/V)

3.3 Inspecting the packaging

After having received the spectrometer, inspect the packaging for damages.

⚠ CAUTION

Possible damage to the delivered spectrometer because of transport damage

Non-observance of the following safety instructions could result in injury.

➢ Inspect the packaging for damages. If there are signs of damage contact shipping company.

➢ A spectrometer delivered in a damaged packaging may be damaged as well. Therefore, in this case do not put the spectrometer into operation. Contact Bruker instead. (See section 1.6.)

3.4 Transporting the spectrometer

The spectrometer has to be carried by at least four persons. Attach the supplied transport handles to the right and left spectrometer side as shown in figure 3.1 using 12 screws (M5 x 16). After having transported the instrument to its destination place, you can remove the transport handles again. Due to the spectrometer weight (ca. 120 kg), this method of transport is suited only for very short distances.

For transporting the spectrometer over longer distances, it is recommended to use a wheeled table, for example.

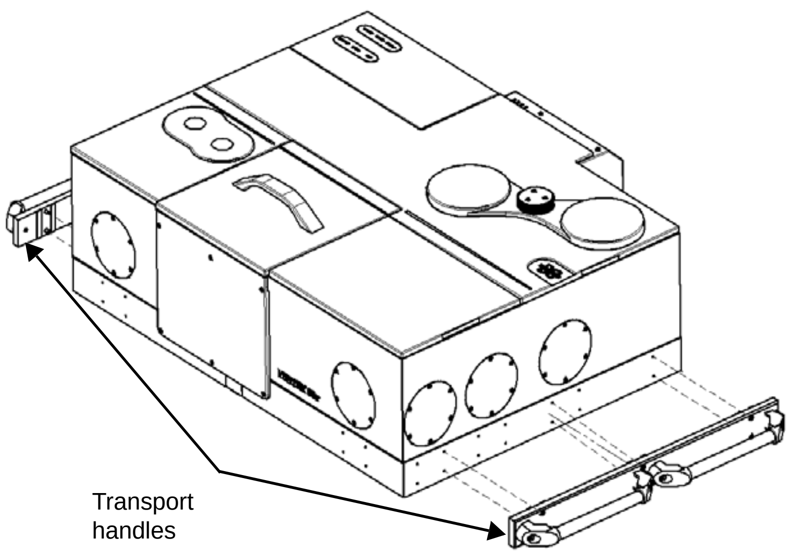


Figure 3.1: Installing the transport handles

⚠ CAUTION

Injury and/or spectrometer damage due to an inadequate method of transport

Non-observance of the following safety instructions could result in injury.

➢ For short-distance transport, the spectrometer has to be carried by at least four persons. Pay attention to the spectrometer weight (ca. 120 kg) Install the supplied transport handles.

➢ For long-distance transport, put the spectrometer on a wheeled table or use a fork lifter, for example. To avoid damages, transporting the spectrometer in original packing is recommended.

3.5 Site requirements

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

Space requirements:	• Spectrometer dimensions: 85cm x 71cm x 31cm (width x depth x height) (For exact spectrometer dimensions refer to appendix D.) • At the rear side, the spectrometer requires a clearance of at least 25cm (10“). • The spectrometer should be placed on a stable and horizontal base. Note that the basic instrument has a weight of about 120 kg.
Environmental requirements:	• Temperature range: 18°C - 35°C (64°F to 95°C) • Temperature variations: max. 1°C/h and max. 2°C/day (Temperature variations can impair the results of long-term measurements.) • Humidity (non-condensing): ≤ 80% (relative humidity) • Installation site: in a closed room, max. 2000m above sea level • The spectrometer should not be installed near vibration sources (e.g. ventilation hoods, air conditioners, motors elevators) or in rooms with intense floor vibrations. • The spectrometer should not be installed near 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. These devices can interfere with the spectrometer and cause spectrometer malfunction. Ensure that these types of devices are not connected to the same electrical circuit as the spectrometer.

Compressed air:	• pressure: between min. 1.0 bar (14.5 psi) and max. 2.0 bar (29 psi) • flow rate: ca. 100 l/h • compressed-air properties: dry and clean air (oil-free and dust-free, dew point < -15°C) or dry and clean nitrogen gas Note: The local compressed air supply line needs to be dimensioned for a PVC hose having an outer diameter of 6mm.
Purge gas supply requirements:	• dry air or nitrogen gas (dew point < -40°C corresponds to a degree of dryness of 128ppm humidity) • oil-free and dust-free • min. pressure: 1 bar (14.5 psi) • max. pressure: 2 bar (29 psi) • Initial purge gas flow rate should not exceed 500 liters/hour. • Sustained purge gas flow rate should not exceed 200 liters/hour. Note: The local purge gas supply line needs to be dimensioned for a PVC hose having an outer diameter of 6mm.
Power supply:	The spectrometer power supply is realized by the supplied external power supply unit. The external power supply unit has a wide input range which means that it is able to adapt itself to the most common public supply mains. • Input range: 100 - 240 V AC, ~ 2.5V, 50 - 60 Hz • Output: 24 V DC, 4.75 A, max. 90 W Connect the spectrometer only to a socket outlet with earthing contact that complies with VDE 0620-1 or IEC! The spectrometer is constructed for the connection to a SELV (safety extra low voltage) circuit. For safety reasons, make sure that the interfaces of electric accessories connected to the spectrometer comply with SELV (safety extra low voltage) circuit requirements. Normally, this condition is met if the accessory design is based on the requirements described in EN 61010 or EN 60950. If there are problems concerning main power supply (e.g. brownouts, power surges, frequent thunderstorms or power blackouts) use an UPS unit (Uninterruptible Power Supply) to ensure an uninterruptible power supply and consequently an operation without interruptions.
Possibilities of interrupting the mains power supply:	The mains power supply of the spectrometer can be interrupted as follows: • by pulling the mains plug of the power cord • by pulling the power cord from the external power supply unit • by switching off the spectrometer using the ON / OFF switch at the spectrometer rear side

External devices:	• Line-powered accessories connected to spectrometer interfaces (e.g. Ethernet) have to have special electrical disconnecting features. The electric circuits of these interfaces have to comply with the requirements imposed on SELV circuits (safety extra low voltage circuit). i Typically, this is achieved when connecting SELV circuits to each other. In general, the interface meets the requirement if the device complies with the regulations outlines in EN 61010 (Safety regulations for laboratory equipment) or EN 60950 (Safety for information technology facilities).

3.6 Connecting the spectrometer to the power supply

3.6.1 General information

The spectrometer power supply is realized by an external power supply unit. The external power supply unit plus power cord and low-voltage cable are included in the standard delivery scope of the spectrometer.

The external power supply unit has a wide input range which means that it is able to adapt itself to the most common public supply mains.

- Input range: 100 - 240 V AC, ~ 2.5V, 50 - 60 Hz
- Output: 24 V DC, 4.75 A, max. 90 W

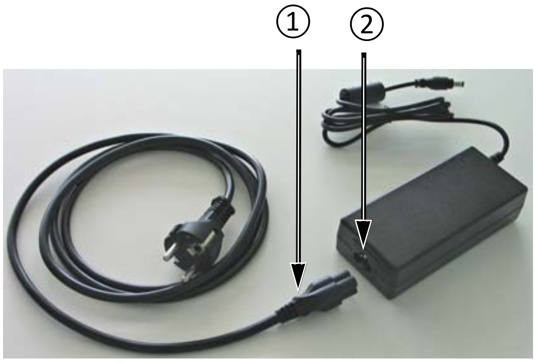
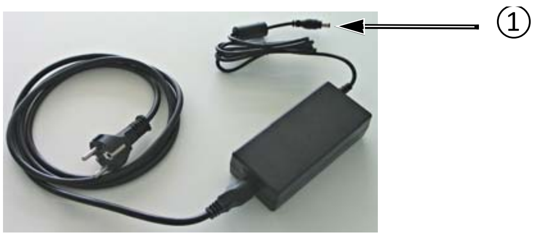
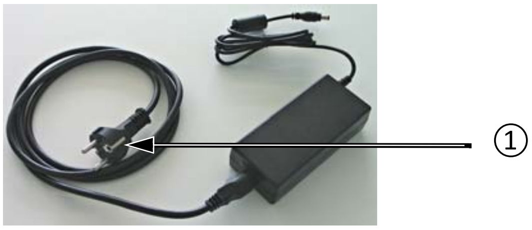
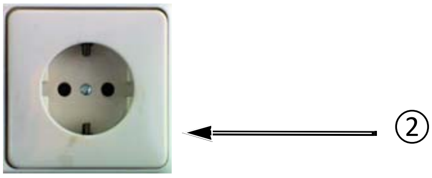
i Depending on the local conditions, the original power cord may need to be exchanged for a power cord that complies with the standards of the country in question. Ensure that the installed power cord has the approval of the local authority (UL for US, CSA for Canada or VDE for Europe).

3.6.2 Safety note

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. Provide for sufficient air circulation.
- Position the external power supply unit in such a way that it does not present a trip hazard.
- 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!

3.6.3 Procedure

1		Make sure that the spectrometer is switched off. To do this, check the setting of the ON/OFF switch ①.
2		Connect the power cord ① to the C5 connector of the external power supply unit ②.
3	 	Connect the low-voltage cable ① to the low-voltage socket ② at the spectrometer rear side.
4	 	Connect the power plug ① of the power cord to the mains socket outlet ②. **WARNING:** Connect the power cord only to a socket outlet with earthing contact. Make sure that the socket complies with IEC. Otherwise, there is the risk of injury and/or property damage!

3.7 Connecting the spectrometer to a compressed-air line

3.7.1 General information

The linear scanner of the spectrometer is supported by an air bearing. For a proper functioning of the linear scanner, the spectrometer needs to connected to a compressed-air line. The compressed-air supply has to meet the following requirements:

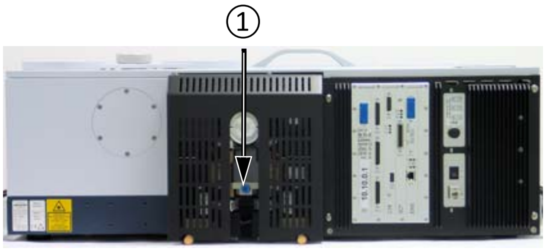
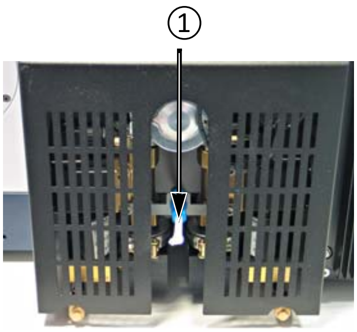
- Pressure: between minimum 1.0 bar (14.5 psi) and maximum 2.0 bar (29 psi)
- Flow rate: about 100 l/h
- Gas: dry and clean air or nitrogen gas (oil-free and dust-free, dew point < -15°C)

NOTE

➢ We **do not** recommend connecting the spectrometer to a compressor as this connection requires in addition a water separator and/or an oil separator in order to prevent oil and/or water from entering the interferometer air bearings. Take into consideration that oil and/or water which enters the air bearings can cause a severe interferometer problem! Bruker Optik offers suitable compressors, dryers and combined systems.

3.7.2 Procedure

➢ A compressed air hose (length: ca. 5 m, OD: 6mm) is included in the delivery scope of the standard spectrometer configuration.

1		Screw off the coupling nut from the connecting piece ①.
2		Pull the plug ① out of the connecting piece.
3		Pull the hose through the coupling nut.

4		Slip the hose over the connecting piece and screw the coupling nut tightly to the connecting piece ①.
5	Connect the hose to the local compressed-air supply line. ☞ The supplied compressed-air hose has a length of about 5m. Note that the actually required hose length depends on the conditions at your installation site. So possibly you need to install an extension hose. Moreover, depending on the connecting piece of your compressed-air supply line, an adapter may be required.	

3.8 Connecting the spectrometer to the vacuum pump

3.8.1 General information

The attachment flange for connecting the vacuum pump is at the spectrometer rear side. Figure 3.2 shows the valve block with removed cover.

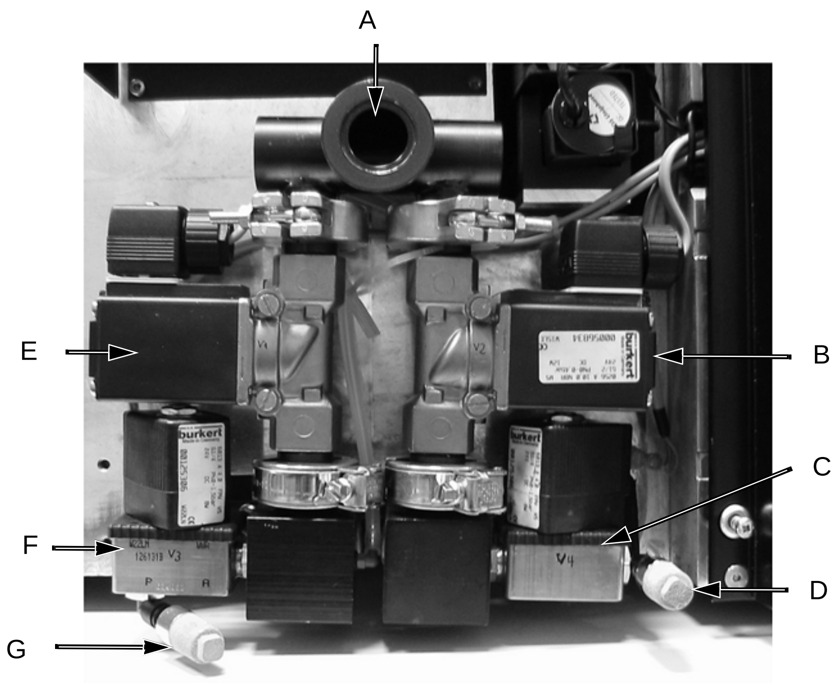


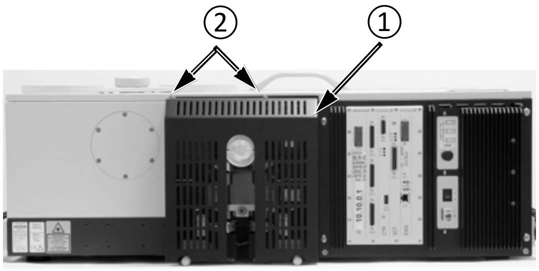
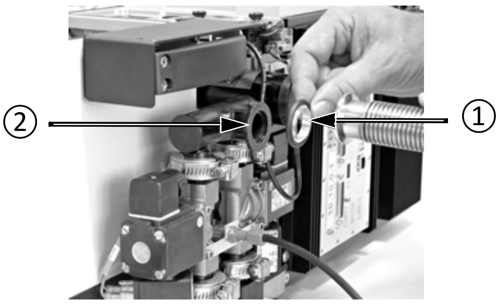
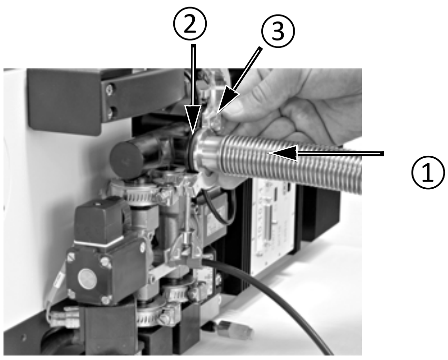
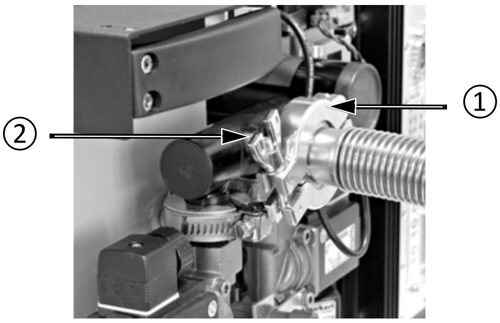
Figure 3.2: Valve block (Spectrometer rear side)

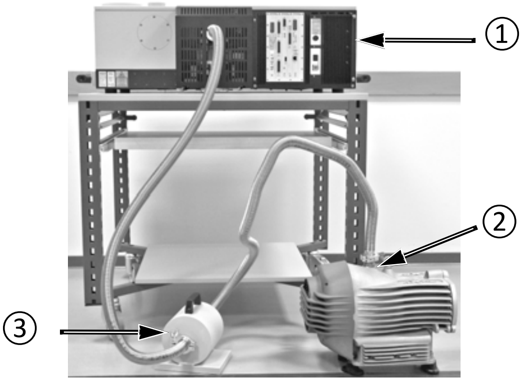
Figure 3.2	Component / Control element
A	Attachment flange (NW25 flange) for the vacuum pump
B	Valve for evacuating the sample compartment
C	Valve for venting the sample compartment
D	Opening for venting the sample compartment Note: When purging the spectrometer this port is used as purge gas inlet for the sample compartment.
E	Valve for evacuating the optical bench
F	Valve for venting the optical bench
G	Opening for venting the optical bench (Note: When purging the spectrometer this port is used as purge gas inlet for the optical bench.

When VERTEX80v is used as a vacuum spectrometer, the two vent openings are covered by a plug made from sintered-powder metal which is air-permeable (i.e. the spectrometer can be vented with the plugs installed on the vent openings). When the spectrometer is vented, these plugs function like a filter preventing particles from entering the spectrometer together with the influent air.

The required connecting components (2x flexible metal hoses, 4x hose clamps and 4x sealing rings) are included in the standard delivery scope.

3.8.2 Procedure

1		Remove the valve block cover ① at the spectrometer rear side. To do this, loosen the two Allen screws ② using a hex key (size 3mm) and pull off the valve block cover ①.
2		Install the sealing ring ① at the flange port ②.
3		Press the flexible metal hose ① against the flange port ② and attach the hose to the flange port using a hose clamp ③.
4		Secure the hose clamp ① by fastening the wing screw ②.

5		☞ During operation, the vacuum pump ② generates vibrations. In order to prevent these vibrations from being transferred to the spectrometer ① via the flexible metal hose, a vibration absorber ③ has to be installed between the vacuum pump ② and the spectrometer ①. (Note: The vibration absorber is included in the standard delivery scope.) The procedure for connecting the flexible metal hose to the vacuum pump and to the vibration absorber is identical to the procedure (step 1 to 4) described above.

Attention: Make sure that the vibrating metal hoses do not come into contact with the table on which the spectrometer is placed.

For detailed information about the vacuum pump (e.g. installation, operation, maintenance), refer to the user manual provided by the vacuum pump manufacturer.

3.9 Connecting the spectrometer to the purge gas supply line

3.9.1 General information

As an alternative to the vacuum operation, the spectrometer can be purged with either dry air or dry nitrogen gas.

The spectrometer has two purge gas inlets; one for purging the sample compartment and the other for purging the optical bench. The purge gas inlets are at the spectrometer rear side. Figure 3.3 shows the valve block with removed cover.

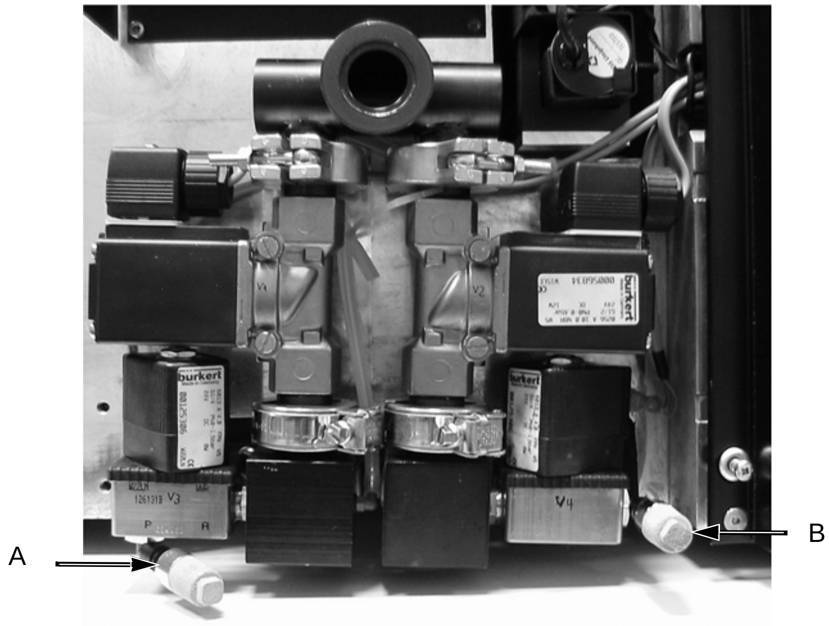


Figure 3.3: Purge gas inlets (Spectrometer rear side)

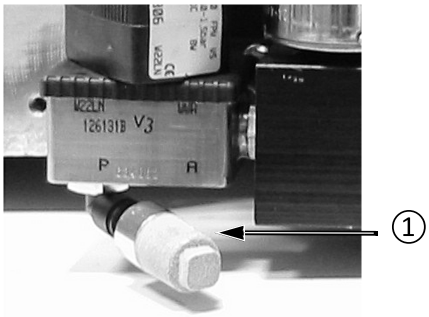
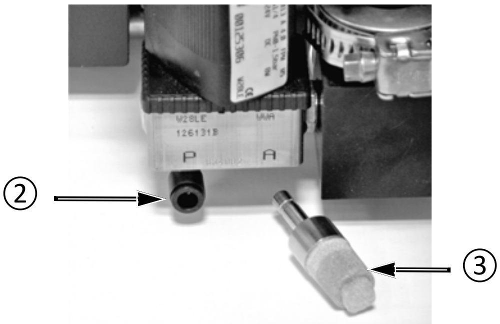
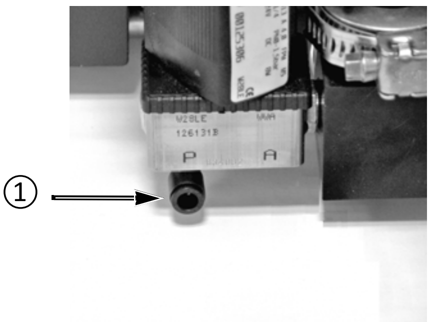
Figure 3.3	Purge gas inlet for ...
A	Purge gas inlet for optical bench (Figure 3.3 shows the purge gas inlet with installed plug.) (Note: In case of vacuum operation, it is the vent opening for venting the optical bench.)
B	Purge gas inlet for sample compartment (Figure 3.3 shows the purge gas inlet with installed plug.) (Note: In case of vacuum operation, it is the vent opening for venting the sample compartment.)

The purge gas supply has to meet the following requirements:

- dry air or nitrogen gas (dew point < -40°C corresponds to a degree of dryness of 128ppm humidity)
- oil-free and dust-free
- min. pressure: 1 bar (14.5 psi)
- max. pressure: 2 bar (29 psi)
- initial purge gas flow rate should not exceed 500 liters/hour
- sustained purge gas flow rate should not exceed 200 liters/hour

3.9.2 Procedure

i The required hoses are not included in the standard delivery scope. Normally, it is the operating company's duty to provide the hoses of the required length (PVC hose, outer diameter: 6mm). Make sure that the hose is rated for the indicated operating pressure. Only in case the purge option S316/V has been ordered, the required hoses including an air flow regulator are included in the delivery scope of the spectrometer.

1	 	Remove the plug from the purge gas inlet ①. To do this, press the lock ring ② inwards and pull out the plug ③.
2		Insert the hose into the purge gas inlet ①.
3	Connect the other end of the hose to the local purge gas supply line.	

Depending on whether you want to purge either only the sample compartment or only the optical bench (i.e. interferometer compartment and detector compartment) or both compartments, there are two variants for connecting the hose.

For purging either the sample compartment or the optical bench

This variant requires a stiff PVC hose with an outer diameter of 6mm.

Remove the plug from the purge gas inlet of either the optical bench (A in fig. 3.3) or the sample compartment (B in fig. 3.3) and insert the hose in the purge gas inlet.

Connect the other end of the hose to the local purge gas supply line.

For purging both the sample compartment and the optical bench

This variant requires a stiff PVC hose (T-shaped) with an outer diameter of 6mm.

Connect the main end of the T-shaped hose to the local purge gas supply line.

Remove the plugs from both purge gas inlets at the spectrometer rear side (A and B in fig. 3.3) and insert the other two ends of hose in the purge gas inlets.

3.10 Connecting the spectrometer to a PC

3.10.1 General information

Basically, the following connection variants are possible:

- Connecting the spectrometer directly to a stand-alone PC (It is the standard variant.) See fig. 3.7.
- Connecting both the spectrometer and PC to a network. See fig. 3.8.
- Connecting the spectrometer to a network computer. See fig. 3.9.

Depending on the connection variants, two different data cable types are required:

Data cable type	For realizing the following connection variant	Included in the delivery scope
Crossover cable	• Stand-alone operation, i.e. spectrometer is connected to a stand-alone PC. See fig. 3.7. • Spectrometer is connected to a network computer. See fig. 3.9.	Yes (1 item)
Straight through cable	• Spectrometer and PC are connected to a network. See fig. 3.8. • Spectrometer is connected to a network computer. See fig. 3.9.	No **Note**: A straight through data cable, category 5, with RJ45 plugs for the Ethernet standard 10/ 100Base-T is required. **Note**: The data cable length should not exceed 100m (without repeater).

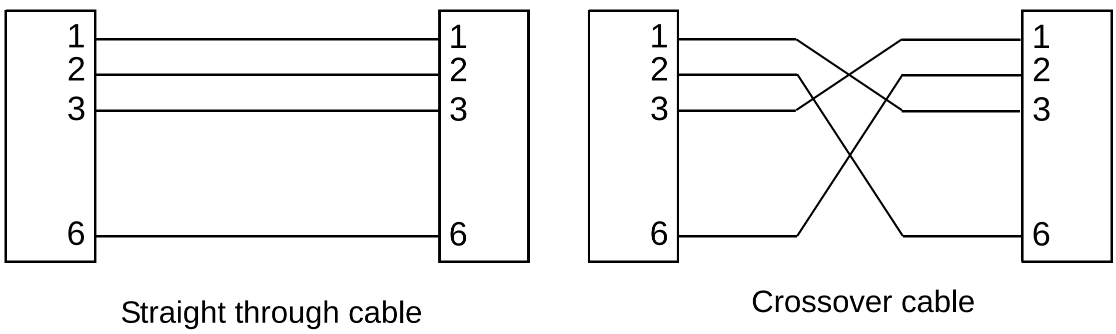


Figure 3.4: Schematic presentation of the different data cable types

Figure 3.5 and 3.6 illustrate the locations of the Ethernet ports for connecting the data cable(s).

Figure 3.5: Spectrometer rear side - Ethernet connector

Fig. 3.5	Ethernet port
A	labelled ETH

Depending on the connection variant, the data cable is connected to different Ethernet ports at the PC. (For information about possible connection variants, see section 3.10.2.)

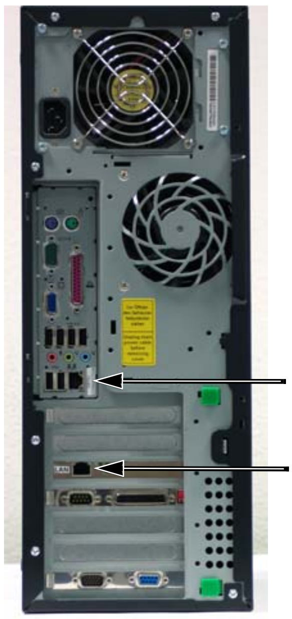


Figure 3.6:PC rear side - Ethernet connectors

Fig. 3.6	Ethernet port
A	labelled OPTIC CONNECTOR **Note:** At this Ethernet port, connect only a crossover data cable.
B	labelled LAN **Note:** At this Ethernet port, connect only a straight through data cable.

3.10.2 Possible connection variants

Variant A (Standard): Connecting the spectrometer to a stand-alone PC

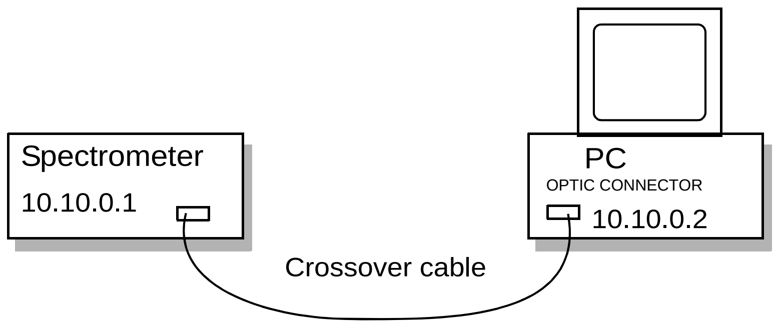


Figure 3.7: Stand-alone operation

The implementation of this connection variant involves the following steps:

1. Connect the supplied crossover data cable to the Ethernet port at the spectrometer rear side (A in fig. 3.5) and to the OPTIC CONNECTOR (A in fig. 3.6) at the PC rear side.

i Only in case you have NOT purchased the computer at Bruker, you have to assign the IP address 10.10.0.2 to the computer to which you want to connect the spectrometer.

2. Check the communication between spectrometer and PC. (See section 3.10.6.)

Advantages of this connection variant:

- Full bandwidth available for data transfer between the spectrometer and PC.
- No access conflicts with other PCs that try to access the spectrometer as well.
- No problems caused by varying data transfer rates.

Disadvantages of this connection variant:

- No remote access to the spectrometer from other PCs on which OPUS is installed.
- PC has no access to the network resources.
- A local printer needs to be connected to the stand-alone PC to print out the measurement results.

Variant B: Connecting both spectrometer and PC to a network

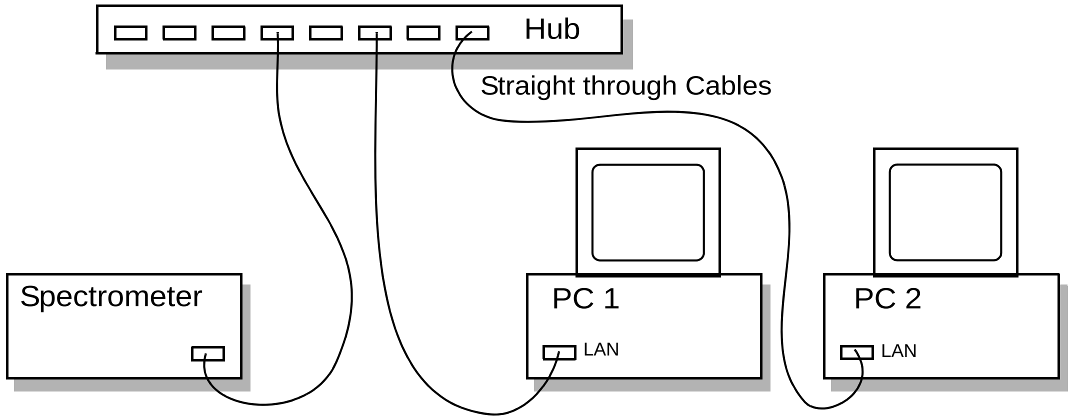


Figure 3.8: Direct integration of the spectrometer into a 10/100Base-T Ethernet network

The implementation of this connection variant involves the following steps:

1. Procure straight through cables category 5, with RJ45 plugs for the Ethernet standard 10/100Base-T. (Note: The number of data cables depends on the number of PCs you intended to connect to the network.)

2. **Spectrometer:** Connect one straight through data cable to the Ethernet port at the spectrometer rear side (A in fig. 3.5) and to the network hub.

3. **PC:** Connect the other straight through data cable to the LAN connector (B in fig. 3.6) at the PC rear side and to the network hub.

4. Assign an IP address to the spectrometer. (See section 3.10.4.) This IP address needs to be defined by your network administrator.

5. Assign an IP address to the PC (LAN network interface card). This IP address needs to be defined by your network administrator.
6. Check the communication between spectrometer and PC. (See section 3.10.6.)

Advantages of this connection variant:

- Remote access to the spectrometer via the internet or the intranet is possible.
- The PC can access to all network resources.

Disadvantages of this connection variant:

- Data cables are required which are not included in the delivery scope.
- Only a fraction of the bandwidth is available for the data transfer between PC and spectrometer. Due to data transfer delays, the measurement time may increase.
- Access conflicts caused by other PCs that try to access the spectrometer as well.

Variant C: Connecting the spectrometer to a network PC

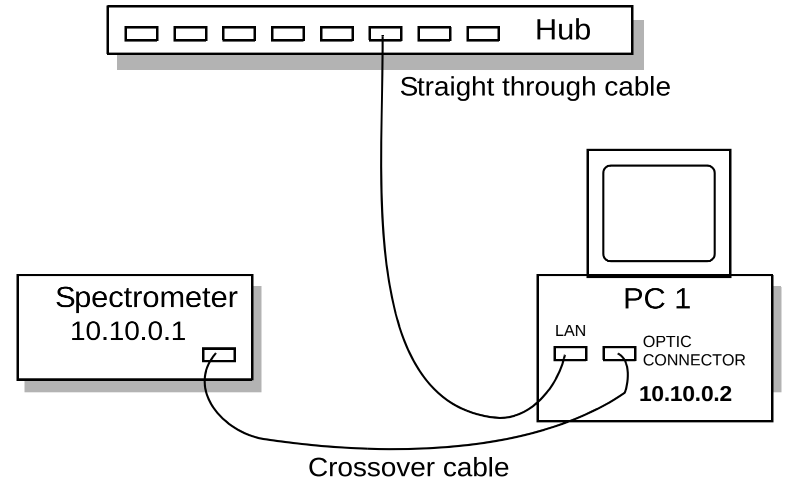


Figure 3.9: Integration of the spectrometer into a 10/100Base-T Ethernet network via a PC

The implementation of this connection variant involves the following steps:

1. Procure a straight through cable category 5, with RJ45 plugs for the Ethernet standard 10/100Base-T.
2. **Spectrometer:** Connect the supplied crossover data cable to the Ethernet port at the spectrometer rear side (A in fig. 3.5) and to the OPTIC CONNECTOR (A fig. 3.6) at the PC rear side.
3. **PC:** Connect the straight through cable to the LAN connector (B fig. 3.6) at the PC rear side and to a network hub.
4. Assign an IP address to the PC (LAN network interface card). This IP address needs to be defined by your network administrator.

i Only in case you have NOT purchased the computer at Bruker, you have to assign the IP address 10.10.0.2 to the computer to which you want to connect the spectrometer.

5. Check the communication between spectrometer and PC. (See section 3.10.6.)

Advantages of this connection variant:

- Full bandwidth is available for the data transfer between the spectrometer and PC.
- Remote access to the spectrometer via internet or intranet is possible.
- The PC has access to all network resources.
- Different data transfer rates for the data exchange between the spectrometer (10/100Base-T) and the network (no restriction) are possible.

Disadvantages of this connection variant:

- A straight through 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.

3.10.3 Network addresses

The possible connection variants require different network addresses for spectrometer and PC.

Network addresses in case of connection variant A (factory-configured variant):

The spectrometer and the PC delivered by Bruker are factory-configured for the stand-alone operation, i.e. all network addresses for this connection variant are already assigned. Only if you did not obtain the PC from 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

Network addresses in case of connection variant B:

- Spectrometer and PC must have an unique IP address each.
- The IP addresses depend on the local intranet and have to be defined by your network administrator.
- In case the spectrometer is to be accessed via internet, you have to specify a gateway address as well. Note: The gateway links your intranet domain to other domains (e.g. domains being part of the internet).
- In case the spectrometer is not to be accessed via internet, set the gateway address to 0.0.0.0.
- In case of the operating system Windows XP, do not specify a gateway.

Important: A wrong IP address can cause problems with other devices connected to the network!

Network addresses in case of connection variant C:

The implementation of this connection variant requires the following preconditions:

- The PC needs to be equipped with two network interface cards.
- Three sets of network addresses have to be available:
  - one set of network addresses for the spectrometer
  - one set of network addresses for the OPTIC CONNECTOR network card in the PC (for the communication between PC and spectrometer)
  - one set of network addresses for the LAN network card in the PC (for the communication between PC and 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

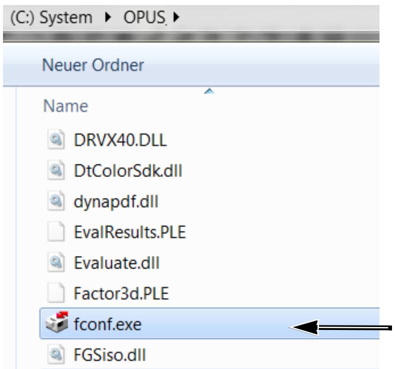
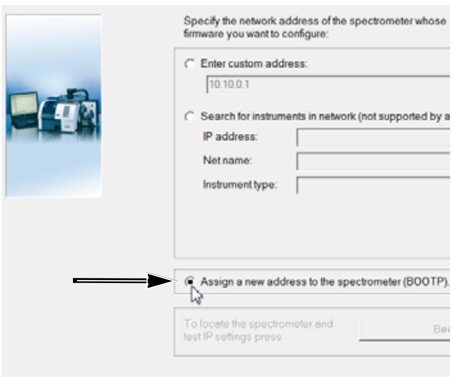
3.10.4 Assigning a network address to the spectrometer

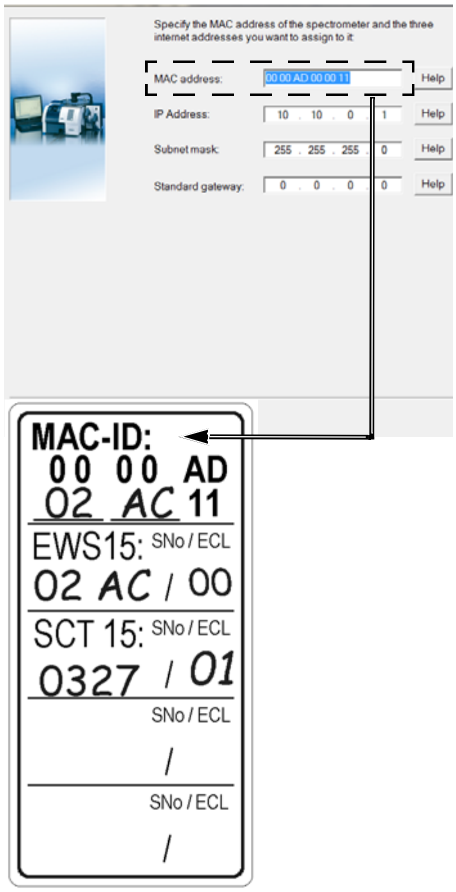
General information

The spectrometer is delivered with the factory-assigned standard IP address 10.10.0.1, i.e. in case of connection variant A and C you need not assign network addresses to the spectrometer.

Only in case of connection variant B (i.e. connecting the spectrometer directly to a network, see fig. 3.8), different spectrometer network addresses are required. They need to be defined by your network administrator and assigned to the spectrometer using the FCONF program (Firmware Configuration). This program is part of the OPUS software.

Network address assignment procedure

1		Start the FCON program by double-clicking on *fconf.exe*. ➢ Note: To find the *fconf.exe* file, browse in the file manager to the OPUS program directory.
2		Activate the *Assign a new address to the spectrometer* radio button. Click the *Next* button.

<table>
<tr>
<td>3</td>
<td>


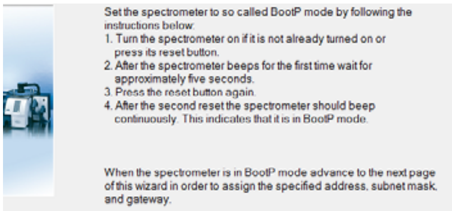
</td>
<td>
Enter the MAC address, the new IP address, the subnet mask address and the gateway address.

➢ You find the MAC address on a label at the spectrometer rear side. (Always keep the MAC address on the label up to date and legible. A wrong MAC address will lead to confusion!)

➢ Note: The MAC address (<u>M</u>edia <u>A</u>ccess <u>C</u>ontrol) is the address of the network adapter (network interface card) which is integrated in a device. This address allows an unique identification of a device connected to a network.

➢ The IP address, the subnet mask address and the gateway address depend on the actually implemented connection variant between PC and spectrometer. (See section 3.10.3.)

☞ The Help buttons provide additional information on how to fill in the different entry lines.

Click the Next button.
</td>
</tr>
<tr>
<td>4</td>
<td>


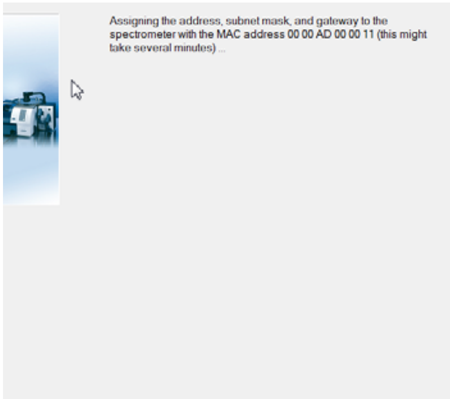
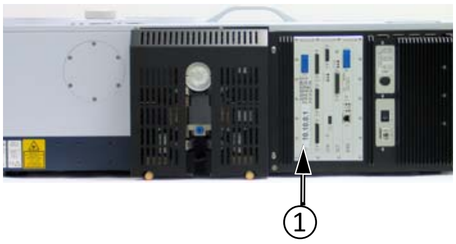
</td>
<td>
➢ Now the FCONF program prompts you to set the spectrometer into BootP-mode.

To do this, follow the on-screen instructions.

☞ Note: The reset button (labelled RES) ① is at the spectrometer rear side.

As soon as the spectrometer is in the BootP mode, click the Next button to start the procedure.

☞ Note: Otherwise, the BootP mode will be canceled automatically after 2 minutes.
</td>
</tr>
</table>

<table>
<tr>
<td>5</td>
<td>
</td>
<td>➢ The assigning process starts immediately and may take several minutes.
➢ If the assigning process has been finished successfully, a message confirms the successful completion and the spectrometer automatically reboots.
➢ Now the spectrometer starts up with the newly-assigned network addresses and can be accessed by the PC.</td>
</tr>
<tr>
<td></td>
<td>
</td>
<td>In case you have assigned a new IP address to the spectrometer, replace the removable label (1) at the spectrometer rear side by a new one showing the new IP-address.
➢ Important: Always keep the IP address on the label at the spectrometer rear side up-to-date. A wrong IP address will lead to communication problems between spectrometer and PC!</td>
</tr>
</table>

3.10.5 PC network address

By default, the PC supplied by Bruker is equipped with two network interface cards labelled OPTIC CONNECTOR and LAN. The network interface card OPTIC CONNECTOR is factory-assigned to the IP address 10.10.0.2, i.e. the PC is factory-configured for the standard connection variant (i.e. connecting the spectrometer to a stand-alone PC). See fig. 3.7, connection variant A.)

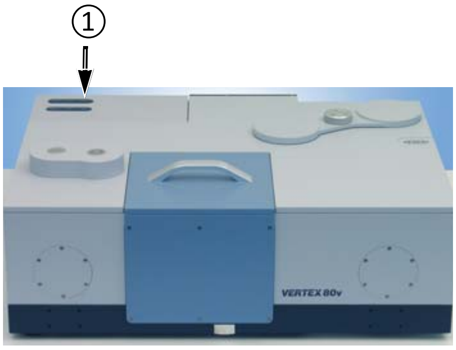
In case of connection variant B (fig. 3.8) and variant C (fig. 3.9), your network administrator has to define the network addresses for the PC. These addresses need to be assigned to the network interface card LAN of the PC.

In case you have not obtained the PC from Bruker, you have to assign the correct network addresses to the network interface card(s) of the PC to which you connect the spectrometer. Note: The network address for the PC depend on the implemented connection variant. (See to section 3.10.3.) In case of connection variant C (fig. 3.9), make sure that the PC is equipped with two network interface cards.

3.10.6 Checking the communication between the spectrometer and the PC

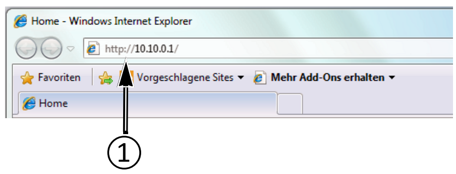
After having connected the data cable(s) and, if required, assigned different network addresses to the spectrometer and/or the PC, it is recommended to check the communication between the spectrometer and the PC. To do this, proceed as follows:

<table>
<tr><td>1</td><td>
</td><td>Switch on the spectrometer using the ON/OFF switch (1) at the spectrometer rear side.

Switch on the PC.</td></tr>
<tr><td>2</td><td>
</td><td>Wait until the spectrometer and the PC have finished booting up and are ready to operate.

➢ Note: The operating status of the spectrometer is indicated by the STATUS LED (1) at the spectrometer top side:
• red STATUS LED: Spectrometer is not ready to operate.
• green STATUS LED: Spectrometer is ready to operate.</td></tr>
<tr><td>3</td><td colspan="2">Start the Internet browser.

Check whether the Internet browser is not in the offline mode.

Ensure that the Internet browser does not use a proxy server, or at least not for addresses of direct access in the 10.10.x.x-range.</td></tr>
<tr><td>4</td><td>
</td><td>Enter the spectrometer IP address in the Internet browser entry field (1) and press the ENTER key.</td></tr>
<tr><td>5</td><td>
</td><td>☞ In case of a successful communication between spectrometer and PC, the Internet Explorer now displays the home page of your spectrometer firmware.</td></tr>
<tr><td></td><td colspan="2">☞ If the communication fails the Internet browser shows a blank page. In this case, check the spectrometer IP address for correct spelling. If this action does not solve the problem, see section 7.5.8.</td></tr>
</table>

4 Overview

This chapter provides an overview of all user-relevant external and internal spectrometer components.

4.1 External components

4.1.1 Spectrometer compartments

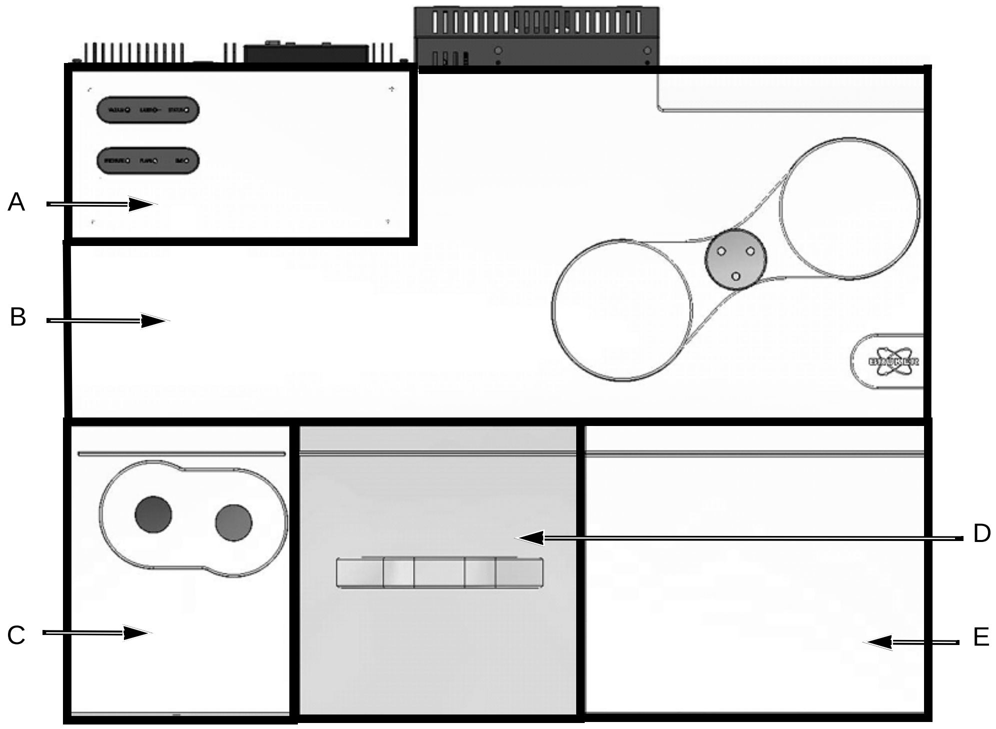


Figure 4.1: General spectrometer overview (Top view)

Fig. 4.1	Spectrometer compartment
A	Electronics compartment
B	Interferometer compartment
C	Detector compartment
D	Sample compartment
E	Beam direction control compartment

The detector compartment, the interferometer compartment and the beam direction control compartment are not separated from each other but form one compartment. All spectrometer compartments are accessible by removing the corresponding cover.

4.1.2 Status indicator board

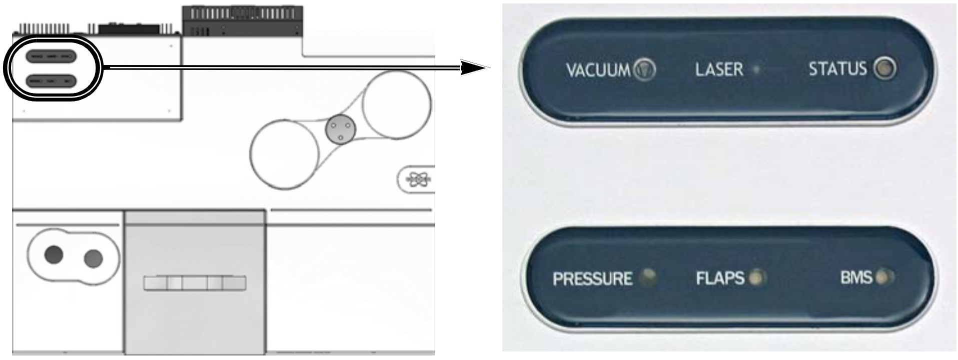


Figure 4.2: Status indicator board

The color of the six status indicator board LEDs gives a general indication of the operating status of the corresponding spectrometer component.

Moreover, the color of the VACUUM LED indicates the current pressure situation inside the spectrometer compartments (i.e it shows whether a certain compartment is being evacuated/vented just now or is already evacuated/vented).

In case one of these LEDs lights up red indicating a spectrometer malfunction refer to chapter 7 for troubleshooting.

VACUUM

The color of VACUUM LED depends on the current pressure situation inside the individual spectrometer compartments. The following table explains the meaning of the different LED colors:

LED is off.	Sample compartment and optical bench are vented.
LED flashes green.	Sample compartment and optical bench are being either evacuated or vented.
LED lights up green.	Sample compartment and optical bench are evacuated. The ultimate vacuum is achieved.
LED flashes yellow.	Sample compartment is being either evacuated or vented. (In case the sample compartment is already vented, it flashes yellow also when the optical bench is being vented.)
LED lights up yellow.	Sample compartment is vented.
LED lights up red.	When the spectrometer is being evacuated, but a certain threshold pressure value is not reached within a certain period of time (i.e. the ultimate vacuum is not achieved). A red VACUUM LED indicates a problem. See section 7.5.1.1 for troubleshooting.

LASER

LED lights up green.	The laser is on and the laser signal is OK.
LED lights up red.	Normally, a red LASER LED indicates a laser problem, for example: • Laser power is too weak or • Laser beam is blocked or • Laser module is defective or • Laser module is out of alignment. ☞ See section 7.5.1.2 for troubleshooting. ➢ **Important note:** This LED also lights up red during the spectrometer initialization phase. In this case, there is not any laser problem. After the spectrometer initialization is completed successfully, this LED turns automatically to green.

STATUS

LED lights up green.	The spectrometer is in proper operating condition.
LED lights up red.	Normally, a red STATUS LED indicates a spectrometer problem. ☞ See section 7.5.1.3 for troubleshooting. ➢ **Important note:** This LED also lights up red during the spectrometer initialization phase. In this case, there is not any laser problem. After the spectrometer initialization is completed successfully, this LED turns automatically to green.

PRESSURE

LED lights up green.	There is sufficient air pressure for the air bearing of the linear scanner.
LED lights up red.	There is **not** sufficient air pressure for the air bearing of the linear scanner. ☞ In this case, measuring is not possible. See section 7.5.1.4 for troubleshooting.

FLAPS

Note: The flaps are vacuum shutters. They are an optional spectrometer feature. The spectrometer is equipped with two flaps. Depending on whether you want to purge, vent or evacuate either the complete spectrometer (i.e. optical bench plus sample compartment) or only either of the two compartments, the two sample compartment wall openings are closed or opened by the flaps. With the flaps closing the two sample compartment wall openings, the flaps provide an air-tight separation of the sample compartment from the optical bench[1].

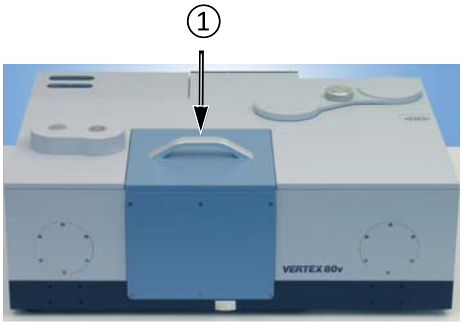
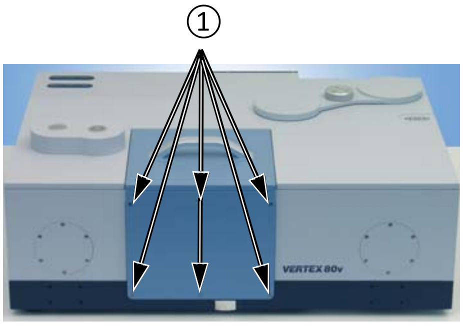
1. The optical bench includes the interferometer compartment, the detector compartment and the beam direction control compartment. These compartments are not physically separated from each other.

LED lights up green.	The flaps are open. Note: In this case, both the sample compartment and the optical bench can be vented or evacuated.
LED lights up yellow.	The flaps are closed. Note: In this case, the sample compartment and the optical bench can be vented or evacuated separately from each other.
LED lights up red.	There is a flap malfunction or an error regarding the flaps. ☞ See section 7.5.1.5 for troubleshooting.

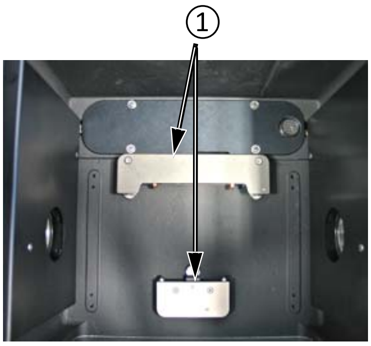
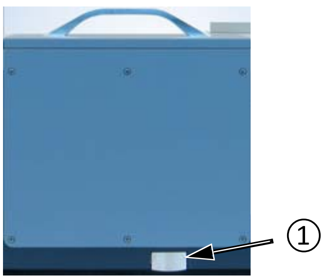
BMS

LED lights up green.	There is a beamsplitter properly installed in the operating position.
LED lights up red.	There is not any beamsplitter installed in the operating position OR the beamsplitter is not installed properly (i.e. it is not locked.) For information about how to install the beamsplitter, see section 5.10. ☞ See section 7.5.1.6 for troubleshooting.

4.1.3 Sample compartment

	Normally, you gain access to the sample compartment from the spectrometer top side by lifting up the blue cover using the handle ①.
	In exceptional cases, if your measurement accessory requires access from the spectrometer front side (e.g. for exchanging the sample), you can remove the blue front cover by loosening the six hex socket screws ① using a hex key size 3mm.

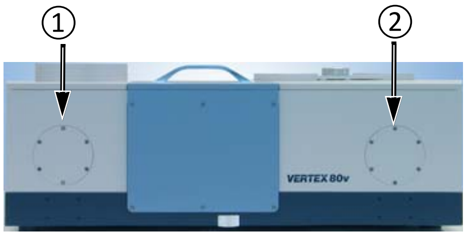
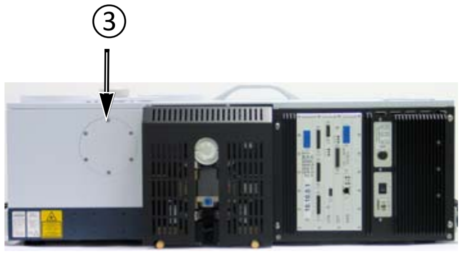
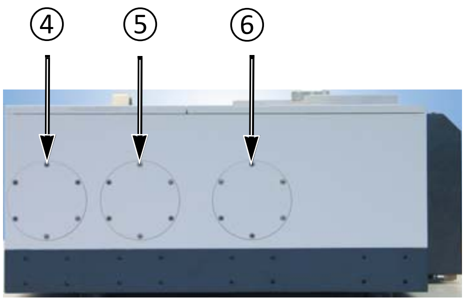
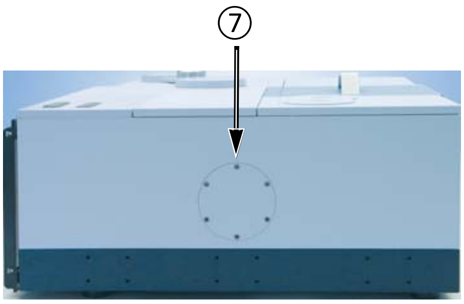
Important note: When you evacuate the sample compartment, do not forget to close the sample compartment properly again!

	The sample compartment is equipped with a QuickLock locking mechanism ① which allows for an exact and reproducible positioning of the accessory in the sample compartment, provided that the accessory is mounted on a QuickLock base plate. For detailed information about how to place a QuickLock-type accessory in the sample compartment, see section 5.4.
	For taking the accessory out of the QuickLock locking mechanism inside the spectrometer compartment, press the QuickLock release button ①. Note: The QuickLock release button is outside the sample compartment.

Bruker offers a large variety of QuickLock-type measurement accessories which are designed for dedicated R&D applications.

4.1.4 IR beam ports

The spectrometer has seven IR beam ports - five IR beam outlet ports and two IR beam inlet ports - allowing the coupling / connection of external accessories and/or components (e.g. FT-IR microscope, Raman module, external light source) to the spectrometer. (See also section 2.4.)

	**Spectrometer front side** ① - Outlet port for a focussed IR-beam (e.g. for connecting a bolometer) ② - Outlet port for a parallel IR-beam (e.g. for connecting a fiber optic coupling module)
	**Spectrometer rear side** ③ - Inlet port for connecting a light emission source (e.g. Hg source)
	**Right spectrometer side** ④ - Outlet port for a parallel IR-beam ⑤ - Outlet port for a parallel IR-beam (e.g. for connecting the FT-IR microscope HYPERION, PMA50 or external sample compartment XSA) ⑥ - Inlet port for connecting a light emission source (e.g. FT Raman module RAM II, water-cooled, high-power MIR source)
	**Left spectrometer side** ⑦ - Outlet port for a parallel IR-beam (e.g. for connecting the FT-IR microscope HYPERION or an external detector chamber)

i External accessories (e.g. FT-IR microscope HYPERION) are coupled to the spectrometer by a Bruker service technician only.

All vacant IR-beam ports are vacuum-tight sealed by covers.

4.1.5 Ports and connectors at the spectrometer rear side

This section provides an overview of only the most important ports, connectors and buttons at the spectrometer rear side.

General overview

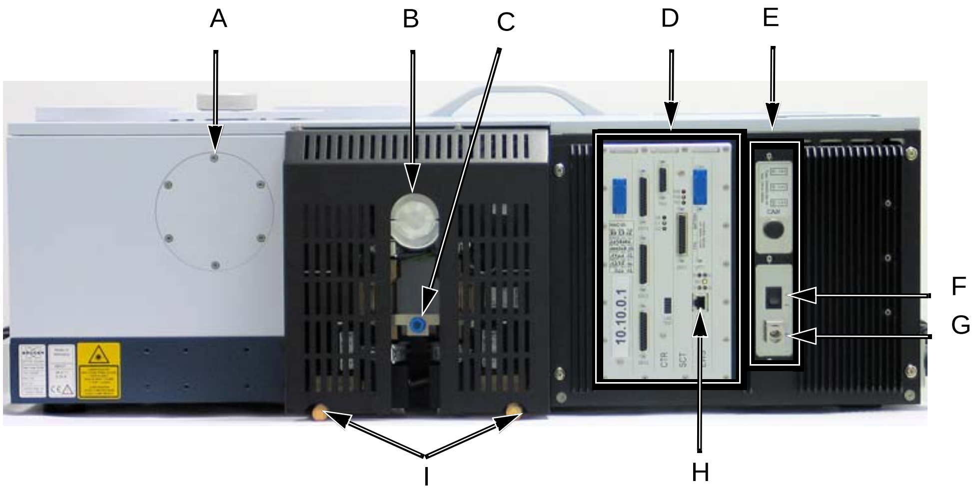


Figure 4.3: Spectrometer rear side - General overview

Fig. 4.3	Ports, connectors and buttons
A	Inlet port for connecting a light emission source (e.g. Hg source)
B	Port for connecting the vacuum pump Note: For information about how to connect the vacuum pump to the spectrometer, see section 3.8.
C	Port for connecting the compressed air hose Note: For information about how to connected the spectrometer to a compressed-air line, see section 3.7.
D	Electronics unit Note: For detailed information, see appendix E.
E	Power supply unit Note: For detailed information, see appendix E.
F	ON/OFF switch (for switch on / off the spectrometer)
G	Low-voltage socket for connecting the spectrometer to the mains supply Note: For information about how to connect the spectrometer to the mains supply, see section 3.6.

Fig. 4.3	Ports, connectors and buttons
H	ETH port for connecting the data cable Note: For information about how to connect the spectrometer to a PC, see section 3.10.
I	Vent openings OR purge gas inlets Note: Depending on whether you evacuate or purge the spectrometer, these two ports serve different purposes. In case of evacuating the spectrometer, these ports serve as vent openings, whereas, when the spectrometer is purged, the purge gas supply hoses are connected to these ports. Note: For information about how to connect the purge gas hoses, see section 3.9.

4.2 Internal components

4.2.1 Overview

Figure 4.4 shows the location of the most important internal spectrometer components.

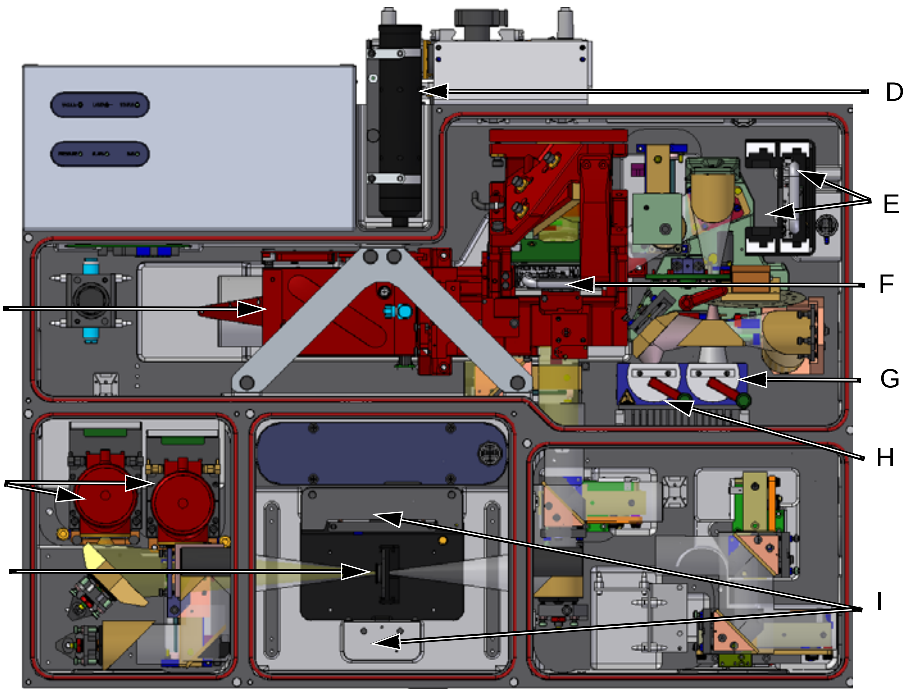


Figure 4.4: Internal spectrometer components (Top view)

Fig. 4.4	Internal spectrometer component
A	Sample holder (included in the standard delivery scope) (Note: This sample holder can be exchanged for any another QuickLock-type measurement accessory.)
B	Detectors (digiTect-type)
C	Linear air bearing scanner (UltraScan, true-aligned)
D	Laser
E	2x beamsplitters (in storage position)
F	Beamsplitter (in operation position)
G	MIR source (in operation position) Note: It is the standard source.
H	NIR source (in storage position) Note: It is an optional source.
I	QuickLock clamping mechanism (for positioning the measurement accessory in the sample comportment)

4.2.2 Source

Standard source

The basic spectrometer configuration is equipped a MIR source which is installed inside the spectrometer (G in fig. 4.4).

The MIR source is a globar (i.e. an U-shaped silicon carbide piece) that emits mid-infrared light. It is air-cooled, i.e. it does not require special cooling.

With this source, spectroscopic measurements in the mid-infrared region can be performed.

Optional sources

The available optional sources provide for different spectral ranges. Note that the combination of source, detector and beamsplitter defines the IR measurement range.

Type of source	Mode of cooling	Installation location
VIS/NIR source (tungsten halogen lamp)	air-cooled	installed in the spectrometer (G in fig. 4.4)
FIR source (mercury lamp)	water-cooled[a]	connected externally to the spectrometer
UV/VIS/NIR source (tungsten lamp)	water-cooled[a]	connected externally to the spectrometer
UV source (deuterium lamp)	air-cooled	connected externally to the spectrometer
High-power MIR source (globar)	water-cooled[a]	connected externally to the spectrometer

a. For the usage of a water-cooled source, a cooling device with closed water circulation is included in the delivery scope.

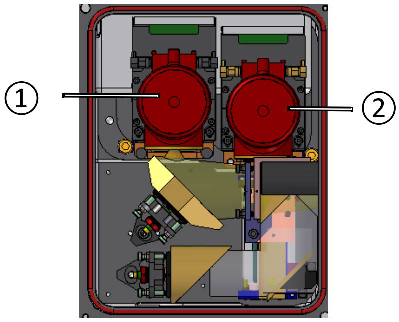
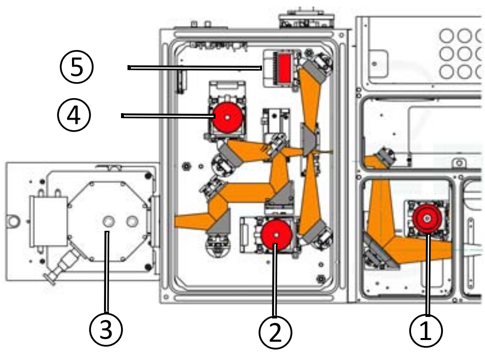
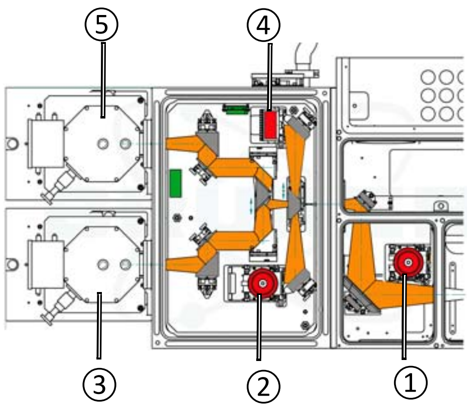
All external sources can be connected to either of the two inlet ports (A or B in fig. 4.5). Only for the FIR source (mercury lamp), the preferred connection port is the inlet port at the spectrometer rear side (A in fig. 4.5).

Figure 4.5: IR beam inlet ports for connecting a source

4.2.3 Detector

General information

All available detectors are equipped with an integrated preamplifier and an A/D converter that converts the analog signal from the detector directly into a digital signal. This so called DigiTect technology allows for an interference-free signal transmission and ensure a high signal-to-noise-ratio.

<table>
<tr><td>
</td><td>The standard spectrometer design allows for a mounting of up to two detectors in the detector compartment of the spectrometer.</td></tr>
<tr><td colspan="2">Optionally, an external detector chamber is available. The external detector chamber is coupled to the IR outlet port at the left spectrometer side. (See section 4.1.4.) With the external detector chamber, the spectrometer can be equipped with up to five detectors as follows:</td></tr>
<tr><td>
</td><td>• 1 detector in the detector compartment of the spectrometer,
• 3 detectors in the external detector chamber and
• 1 bolometer coupled to the external detector chamber</td></tr>
<tr><td>
</td><td>• 1 detector in the detector compartment of the spectrometer,
• 2 detectors in the external detector chamber and
• 2 bolometers coupled to the external detector chamber
➢ Note: With the external detector chamber, the second detector mount in the detector compartment of the spectrometer is not available.</td></tr>
<tr><td colspan="2">The detector which is to be used for the measurement is selected by the user in OPUS.</td></tr>
</table>

Standard detector

The standard detector is a pyroelectric DLaTGS detector which covers a spectral range from 12,000 to 250cm^{-1}, operates at room temperature and has a sensitivity of D*>4x10^{8} cm Hz$^{1/2}$ W^{-1}.

Optional detectors

The available optional detectors provide for different spectral ranges and sensitivities. Note that the combination of source, detector and beamsplitter defines the IR measurement range.

The following optional detectors are available:

Detector	**Spectral range (cm^{-1})**	**Sensitivity**	**Operating temperature / cooling mode**
Mid-Infrared			
DLaTGS with KBr window (Standard)	12,000 - 250	D*>4x10^{8}cm Hz$^{1/2}$W^{-1}	Room temperature
DLaTGS with CsI window	12,000 - 180	D*>4x10^{8}cm Hz$^{1/2}$W^{-1}	Room temperature
MCT narrow band, with BaF_2 window **HARMFUL!**	12,000 - 850	D*:>4x10^{10}cm Hz$^{1/2}$ W^{-1}	Liquid N_2 cooled
MCT mid band, with ZnSe window **TOXIC!**	12,000 - 600	D*:>2x10^{10}cm Hz$^{1/2}$ W^{-1}	Liquid N_2 cooled
MCT broad band, with KRS-5 window **TOXIC!**	12,000 - 420	D*:>5x10^{9}cm Hz$^{1/2}$W^{-1}	Liquid N_2 cooled
Photovoltaic MCT, with BaF_2 window **HARMFUL!**	12,000 - 850	D*:>3x10^{10}cm Hz$^{1/2}$ W^{-1}	Liquid N_2 cooled
MCT/InSb sandwich, with ZnSe window **TOXIC!**	10,000 - 600	D*:>2x10^{10} cm Hz$^{1/2}$W^{-1} (MCT) D*:>1.5x10^{11}cm Hz$^{1/2}$W^{-1}(InSb)	Liquid N_2 cooled
Near-Infrared			
InSb	10,000 - 1,850	D*:>1.5x10^{11}cm Hz$^{1/2}$ W^{-1}	Liquid N_2 cooled
InSb with cold filter	10,000 - 3,100	D*>5x10^{11}cm Hz$^{1/2}$ W^{-1}	Liquid N_2 cooled
Ge detector	11,750 - 5,900	NEP<10^{-15} W Hz$^{-1/2}$	Liquid N_2 cooled
InGaAs diode	12,800 - 5,800	NEP:<2x10^{-14} W Hz$^{-1/2}$	Room temperature
InGaAs diode	12,800 - 4,000	NEP:<2x10^{-13} W Hz$^{-1/2}$	Room temperature

Detector	Spectral range (cm^{-1})	Sensitivity	Operating temperature / cooling mode
Far Infrared			
DLaTGS with PE window	700 - 10	$D^* > 4 \times 10^8 cm\ Hz^{1/2} W^{-1}$	Room temperature
Silicon bolometer	600 - 8 35 - 4*	$NEP < 10^{-13}\ W\ Hz^{-1/2}$	Liquid He cooled (*) Liquid He needs to be pumped off.
Visible & UV			
Silicon diode	25,000 - 9,000	$NEP: < 10^{-14}\ W\ Hz^{-1/2}$	Room temperature
GaP diode	50,000-18,000	$NEP: < 5 \times 10^{-15}\ W\ Hz^{-1/2}$	Room temperature

Some detectors are equipped with windows of which the material is harmful or (very) toxic. During normal spectrometer operation, these materials do not pose any health hazard. However, should such a detector window break because of mechanical impact, be extremely careful.

WARNING

Health hazard because of improper handling of broken harmful or toxic detector window material

Non-observance of the following safety instructions could result in death or serious injury.

- ➢ Avoid generating dust of broken detector window material. This material is harmful or toxic if swallowed or inhaled.
- ➢ Also avoid skin and eye contact.
- ➢ Dispose the harmful or toxic material according to the laboratory regulations and the national regulations.

For detailed information about how to exchange a detector, see section 5.11.

4.2.4 Beamsplitter

Standard beamsplitter

The basic spectrometer configuration is equipped with a KBr beamsplitter which covers a spectral range from 8000 to 350cm^{-1}.

Optional beamsplitters

The available optional beamsplitters provide for different spectral ranges. Note that the combination of source, detector and beamsplitter defines the IR measurement range. The following optional beamsplitters are available:

Beamsplitter	Spectral range (cm^{-1})	Color coding of the beamsplitter handle
Mid-Infrared		
KBr (standard)	8,000 - 350	red
KBr (broad band)	10,000 - 400	red
Near-Infrared		
CaF_2 **HARMFUL!**	15,000 - 1,200	brown
Visible & UV		
CaF_2 NIR/VIS/UV (broad band)	50,000 - 4,000	white
Far-Infrared		
Multilayer (far IR)	680 - 30	metallic
Mylar 25µm	120 - 20	metallic
Mylar 50µm	60 - 10	metallic
Mylar 125µm	22 - 5	metallic
Alignment (glass)	visible	nickel-plated

WARNING

Health hazard because of improper handling of broken harmful beamsplitter material

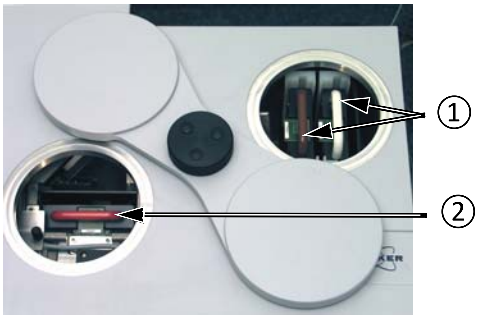
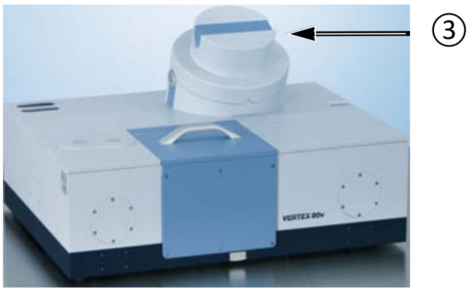
Non-observance of the following safety instructions could result in death or serious injury.

➢ Avoid generating dust of broken beamsplitter material. The material is harmful if swallowed or inhaled.

➢ Also avoid skin and eye contact.

➢ Dispose the harmful material according to the laboratory regulations and the national regulations.

Possible beamsplitter exchanging procedures

	**Manual beamsplitter exchange** By default, there are two beamsplitter storage positions ① and one beamsplitter operating position ② inside the spectrometer. The standard spectrometer design allows for exchanging the beamsplitter only manually. In this case, the optical bench needs to be vented first before you can exchange the beamsplitter.
 	**Software-controlled beamsplitter exchange** In case of the optional automatic beamsplitter changer ③, the time-consuming venting and re-evacuating process is not required because the beamsplitter can be exchanged under vacuum conditions. The beamsplitter exchange is realized by software control only. Note: The automatic beamsplitter changer can be loaded with up to four beamsplitters.

For detailed information about how to exchange the beamsplitter, see section 5.10.

4.2.5 Laser

The spectrometer is equipped with a HeNe laser (D in fig. 4.4) that emits red light with a wavelength of 632.8nm and has a rated power output of 5mW.

The laser controls the position of the moving interferometer mirror (also called "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.

4.2.6 Interferometer

The spectrometer is equipped with an actively aligned UltraScan interferometer (C in fig. 4.4) based on a linear scanner which ensures highest possible spectral resolution (standard: better than $0.2cm^{-1}$, optional: better than $0.07cm^{-1}$).

The linear scanner is supported by an air bearing which requires the connection to a compressed air line. (For detailed information about how to connect the spectrometer to a compressed air line, see section 3.7.)

4.2.7 Sample compartment windows

General information

Basically, there is a circular opening on either sample compartment side. Through the opening in the left sample compartment wall, the IR beam enters the sample compartment. Through the opening in the right sample compartment wall, the IR beam exits the sample compartment.

Optionally, these openings are closed by IR-transparent windows. The windows are either flanged directly to the sample compartment walls or they are mounted on the flaps[1] or they are of telescopic type.

Overview of the available window materials

The following table lists the available window materials including their transmission range, refraction index and chemical properties.

Material	Transmission range (cm^{-1})*	Refraction index n (at 2000cm^{-1})	Chemical properties
Quartz (Infrasil) SiO_2	57,000 - 2,800	1.46	Insoluble in water; soluble in HF
Silicon Si	10,000 - 100	3.42	Insoluble in most acids and bases; soluble in HF and HNO_3
Calcium Fluoride CaF_2	66,000 - 1,000	1.40	Insoluble in water; resistant to most acids and bases; soluble in NH_4 salts
Barium Fluoride BaF_2 **HARMFUL!**	50,000 - 800	1.45	Low water solubility; soluble in acid and NH_4Cl
Sodium Chloride NaCl	28,000 - 580	1.50	Hygroscopic; slightly soluble in alcohol and NH_3
Zinc Selenide ZnSe **TOXIC!**	20,000 - 500	2.43	Soluble in strong acids and in HNO_3
Potassium Bromide KBr	33,000 - 280	1.54	Soluble in water, alcohol, and glycerine; hygroscopic

1. The flaps are vacuum shutters. The purpose of the flaps is to provide an air-tight separation of the sample compartment from the optical bench in case you want to purge, evacuate or vent only either compartment. Note: Flaps are an optional spectrometer feature.

Material	Transmission range (cm^{-1})*	Refraction index n (at $2000cm^{-1}$)	Chemical properties
Cesium Iodide CsI **HARMFUL!**	33,000 - 180	1.74	Soluble in water and alcohol; hygroscopic
KRS-5 (TIBr/I thallium bromide-iodide) **VERY TOXIC!**	16,000 - 250	2.38	Soluble in warm water and bases; insoluble in acids
Polyethylene PE (high density)	600 - 10	1.52	Resistant to most solvents

50% value at a window thickness of 4mm

Some sample compartment windows are of a material which is harmful or (very) toxic. During normal spectrometer operation, these materials do not pose any health hazard. However, should such a window break because of mechanical impact, be extremely careful.

WARNING

Health hazard because of improper handling of broken harmful or toxic window material

Non-observance of the following safety instructions could result in death or serious injury.

➢ Avoid generating dust of broken window material. This material is harmful or toxic if swallowed or inhaled.

➢ Also avoid skin and eye contact.

➢ Dispose the harmful or toxic material according to the laboratory regulations and the national regulations.

➢ Observe also the safety instructions of the attached safety data sheets.

For detailed information about how to exchange a sample compartment window, see section 6.5.

4.3 Optical beam path

Note: The optical beam path shown in fig. 4.6 is the optical beam path of the standard spectrometer configuration.

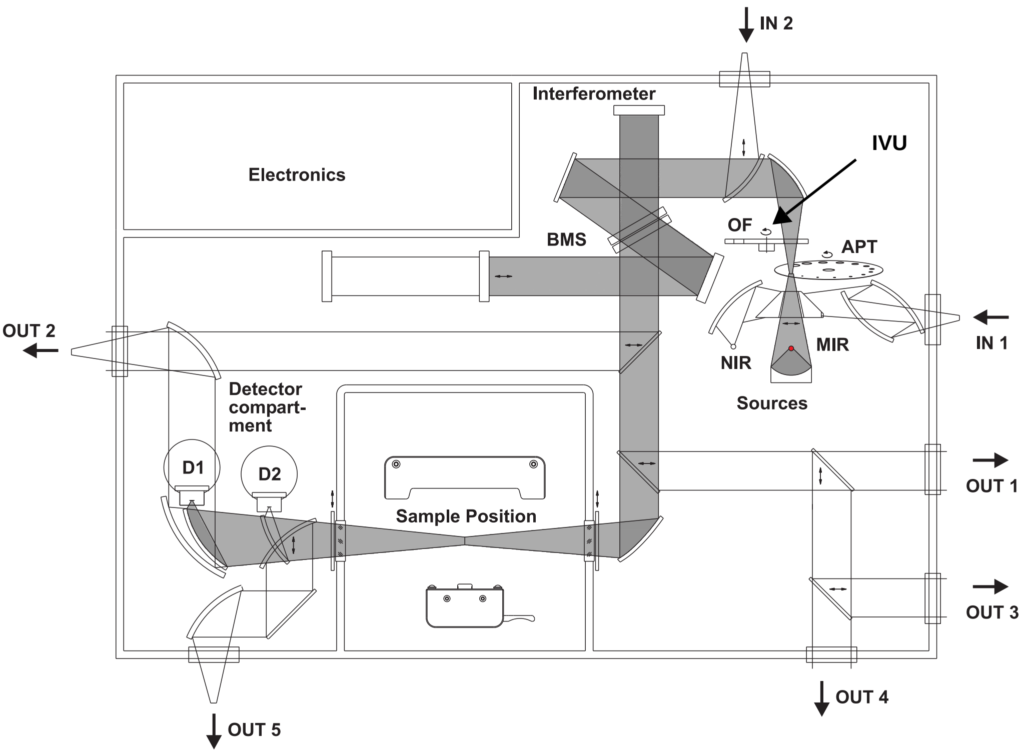


Figure 4.6: VERTEX 80v - Optical beam path

Abbreviation	Explanation
D1	Standard detector
D2	Optional detector
BMS	Beamsplitter
APT	Aperture wheel
IVU / OF	Internal validation wheel / optical filter wheel
IN 1 and IN 2	IR beam inlet port 1 and 2
OUT 1 ... OUT 5	IR beam outlet port 1 to 5

5 Operation

5.1 General information

The spectrometer is completely computer-controlled, i.e. operating the spectrometer (e.g. selecting the correct spectrometer component), performing a spectroscopic measurement as well as evacuating and venting the spectrometer is done using the spectroscopic software program OPUS.

This manual is restricted mainly to the spectrometer-related aspects that are relevant to operating the spectrometer:

- putting the spectrometer into operation and shutting the spectrometer down
- chronological sequence of the individual operating steps during a measurement (general measurement procedure)
- evacuating and venting the spectrometer
- purging the spectrometer
- checking the signal
- extending the spectral range
- cooling the MCT detector

Specifying the measurement parameters and starting a measurement and evaluating the measurement results as well as defining and starting a spectrometer validation test (OQ and PQ) are done exclusively using the spectroscopic software program OPUS. For detailed information about these topics refer to the OPUS Reference Manual. For information about the measurement parameters, see also appendix C.

The standard spectrometer configuration is designed for measurements in the mid infrared region. Optionally, the spectral range can be expanded by exchanging the installed MIR components (source, detector and beamsplitter, if available) for the corresponding optical components that allow measurements in the far or near infrared as well as in the visible or ultraviolet region. (For information about the substitution procedure of these optional components refer to the corresponding sections in this chapter.)

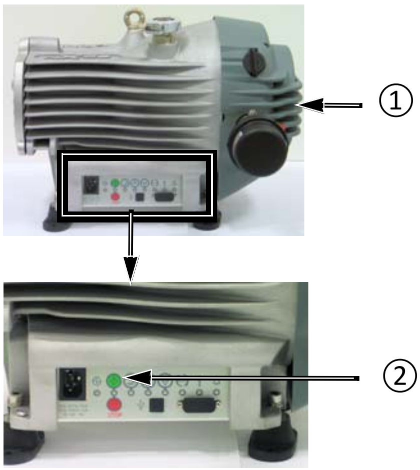
5.2 Putting the spectrometer into operation

Provided that the spectrometer has been shut down as described in section 5.3, put the spectrometer into operation as follows:

<table>
<tr><td>1</td><td>
</td><td>Switch on the spectrometer using the ON/OFF switch ① at the spectrometer rear side.

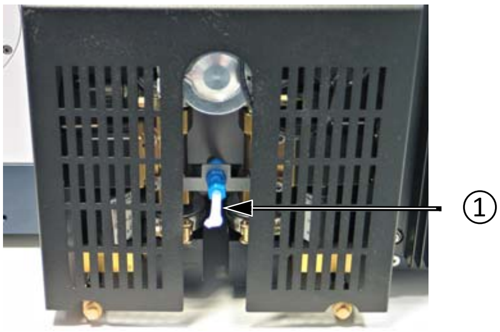
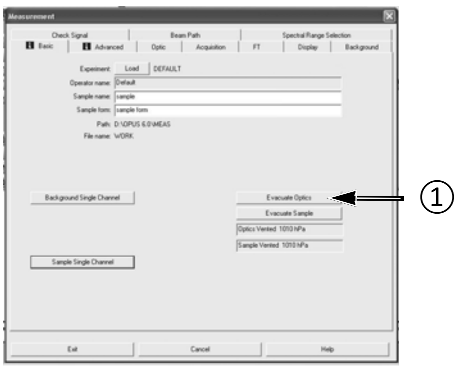
➣ Now the spectrometer starts to initialize. During the spectrometer initialization, the STATUS LED ① lights up red. Note: In this case, there is not any spectrometer problem.

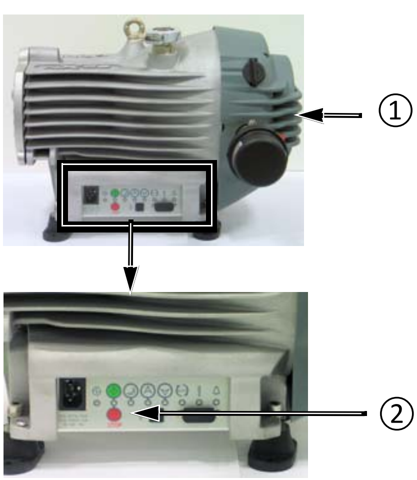
➣ After the spectrometer initialization is completed successfully, the STATUS LED turns automatically to green indicating that the spectrometer is ready to operate.</td></tr>
<tr><td>2</td><td colspan="2">Turn on the compressed air supply.
➣ As a result, the linear scanner starts automatically.
Note: If you have interrupted the compressed air supply by pulling off the hose and sealing the inlet, first vent the spectrometer, remove the plug and connect the hose. (See section 3.7.)</td></tr>
<tr><td>3</td><td colspan="2">Switch on the PC and the monitor.</td></tr>
</table>

4		In case you intend to perform measurements under vacuum conditions, switch on the vacuum pump ① as well. To do this, press the ON-switch ②. Note: For detailed information about the vacuum pump, refer to the user manual provided by the vacuum pump manufacturer.
	☞ After having switched on the spectrometer and evacuated the optical bench, wait at least 15 minutes before starting the first measurement. This allows for the spectrometer to stabilize. ☞ For high-precision measurements, wait at least two hours to allow the laser to stabilize.	

5.3 Shutting down the spectrometer

Ideally, the optical bench of the spectrometer should always be kept under vacuum and the compressed air supply for the air bearing of the linear scanner should not be interrupted even during time of nonuse (e.g. overnight). If, however, the circumstances require a spectrometer switch-off and/or the vacuum pump switch-off and/or an interruption of the compressed air supply, the following shut-down procedure is recommended:

1		Interrupt the compressed air supply by either stopping the supply or pulling off the compressed air hose from the spectrometer. ☞ Note: In the latter case, the spectrometer has to be vented first. Afterwards, seal the inlet using the intended plug ①. ➣ As soon as the compressed air supply is interrupted, the scanner will stop automatically.
2		Evacuate the optical bench of the spectrometer. To do this, click in the OPUS *Measurement* dialog on the *Evacuate Optics* button ①. (See also section 5.6.) ➣ The evacuation will take about 5 minutes.
3		As soon as the optical bench is evacuated completely, switch off the spectrometer using the ON/OFF switch ① at the spectrometer rear side. ➣ In the electroless spectrometer state, all valves (i.e. all valves for evacuating and venting the spectrometer) are closed.

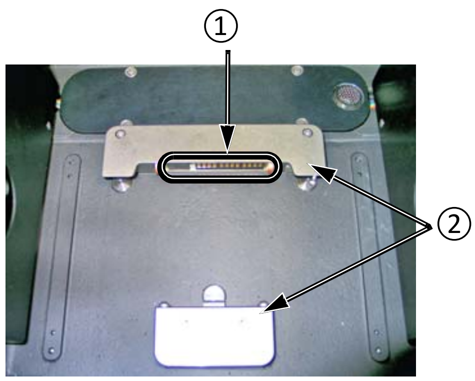
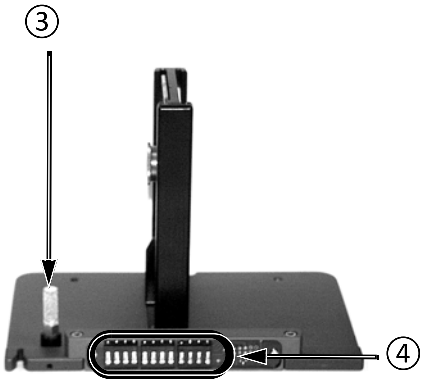
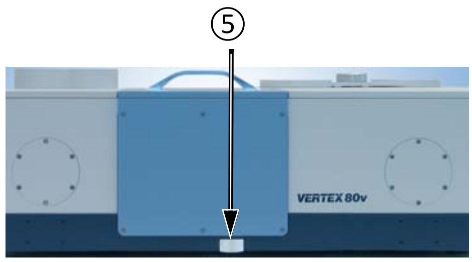
4		Switch off the vacuum pump ①. To do this, press the OFF-switch ②. Note: For detailed information about the vacuum pump, refer to the user manual provided by the vacuum pump manufacturer.
	➢ In this state, the evacuated optical bench of the spectrometer is isolated from the ambient air. So, the optical spectrometer components are protected against air humidity. And they are not current-carrying. In addition, the air bearing of the linear scanner does not need to be supplied with compressed air.	

5.4 Placing an accessory in the sample compartment

5.4.1 QuickLock mechanism

Bruker offers a large variety of measurement accessories designed for dedicated applications. For installing these accessories in the spectrometer, the sample compartment is equipped with an accessory locking mechanism called QuickLock. Therefore, only accessories with a QuickLock-baseplate can be used.

The QuickLock locking mechanism allows for a solid lock and a quick and exact positioning of the accessory in the sample compartment. And the available QuickLock-type accessories ensure an exact and reproducible positioning of the sample in the measurement position.

	**Spectrometer sample compartment (inside view)** ① - Contract strip (electronic connectors for AAR and CAN bus; it is the counterpart to the contact strip at the QuickLock baseplate of the accessory ④) ② - QuickLock mechanism for locking the accessory
	**Standard sample holder with QuickLock baseplate** ③ - Purge gas diffusor for purging the sample compartment with dry air, if desired ④ - Contract strip (electronic connectors for AAR and CAN bus; it is the counterpart to the contact strip at the QuickLock mechanism in the sample compartment ①) Note: This sample holder is included in the standard delivery scope of the spectrometer.
	**Spectrometer (front view)** ⑤ - QuickLock release button

5.4.2 Putting an accessory in the sample compartment

1. Push the contact strip of the accessory QuickLock baseplate gently against its counterpart of the QuickLock mechanism in the sample compartment while tilting the accessory QuickLock baseplate front edge slightly upwards.
2. Put down the accessory QuickLock baseplate and make sure that the accessory QuickLock baseplate is orientated straight.
3. While pressing the release button outside the sample compartment, press the front edge of the accessory QuickLock baseplate downwards until it snaps into the QuickLock mechanism.

➢ As soon as the accessory QuickLock baseplate locks in place, the electronic connections for AAR are established. This is indicated by a beep.

5.4.3 Automatic accessory recognition (AAR)

All QuickLock-type accessories are electronically coded. So, as soon as an accessory locks in place of the spectrometer QuickLock mechanism, it is automatically recognized by the OPUS software program. This software feature is called AAR (Automatic Accessory Recognition). In addition, the OPUS/AAR program performs several predefined OVP tests and loads automatically the corresponding experiment file including the adequate measurement parameter settings and values, provided the user has already defined and stored them for the accessory in question.

Note: When you put a certain accessory in the sample compartment for the very first time, the OPUS/AAR software cannot recognize it because it is not yet registered. In this case, the software prompts you to register the new accessory.

For detailed information about the OPUS software feature AAR, refer to the OPUS Reference Manual. For detailed information about how to define OVP test parameters for certain accessory types, see the Accessory Manager User Manual.

5.4.4 Taking an accessory out of the sample compartment

1. While pressing the release button outside the sample compartment, lift the front edge of the accessory QuickLock baseplate until the baseplate snaps free.
2. Take the accessory out of the QuickLock mechanism in the sample compartment. Be careful not to damage the contact strips.

5.5 General measurement procedure

It is highly recommended to validate the spectrometer performance each day before you start your analytical work by performing a PQ test[1] using OVP[2]. For detailed information about how to validate the spectrometer refer to the OPUS Reference Manual.

The following procedure refers exclusively to measurements under vacuum. In case you intend to perform a measurement not under vacuum, ignore the steps regarding evacuating and venting the spectrometer.

1. If you intend to measure the sample using a special accessory[3], place the accessory (without sample!) in the sample compartment. (See the section 5.4.) If you intend to measure the sample using the standard sample holder, you can skip this step. (Note: This sample holder is included in the standard delivery scope.) Close the sample compartment.
2. Specify the measurement parameters in OPUS. (Note: The standard parameter settings and values are listed in appendix C.)
3. Evacuate the spectrometer (optical bench and sample compartment), if not already done. (See section 5.6.3)
4. Start a background measurement[4] (i.e. **without** a sample being in the sample compartment) by clicking in the OPUS *Measurement* dialog on the *Background Single Channel* button.

☞ Depending on how you intend to prepare your sample (e.g. KBr pellet, mull or sample solution), it is highly recommended to perform the background measurement with either a pure KBr pellet or the pure nujol or the pure solution placed in the sample position. (For detailed information about sample preparation refer to appendix G.)

5. Vent only the sample compartment. (See section 5.6.4.)
6. Put the sample in the sample compartment by positioning the sample in the measurement position. Close the sample compartment.
7. Evacuate the sample compartment. (See section 5.6.3.)
8. Start a sample measurement by clicking in the OPUS *Measurement* dialog on the *Sample Single Channel* button.

☞ **Important:** Perform both the background measurement and the sample measurement with the same parameter settings in OPUS. Ensure that for both measurements, the ambient conditions (water vapor concentration, temperature etc.) are identical or at least nearly identical.

➢ Afterwards, OPUS calculates automatically the result sample spectrum by dividing the sample spectrum (acquired in step 8) by the background spectrum (acquired in step 4).

For detailed information about the OPUS functions for data acquisition, manipulation and evaluation refer to the OPUS Reference Manual.

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1. PQ test - Performance Qualification Test
2. OVP - OPUS Validation Program (It is intended for performing spectrometer validation tests like OQ and PQ.)
3. Bruker offers a wide range of accessories designed for special analytical applications. For detailed information about how to perform a measurement with a particular accessory, refer to the User Instructions delivered with the accessory in question.
4. The purpose of the background measurement is to detect the influence of the ambient conditions (level of air humidity, temperature etc.), the auxiliary materials (e.g. solutions), that are required for preparing the sample, and the spectrometer itself on the spectroscopic measurement result. After the subsequent sample measurement, OPUS calculates automatically the result sample spectrum by dividing the sample spectrum (SSC) by the background spectrum (RSC). In doing so, those spectral bands, that result from the ambient conditions, auxiliary materials and/or the spectrometer, are eliminated from the result sample spectrum.

5.6 Evacuating and venting the spectrometer

5.6.1 Activating the vacuum mode in OPUS

The spectrometer can be operated either in the vacuum mode or in the purge mode. To activate the vacuum mode, select in the OPUS *Measure* menu the *Optic Setup and Service* function. Click on the *Devices/Options* tab and make sure that the *Purge Mode* check box is deactivated. See fig. 5.1.

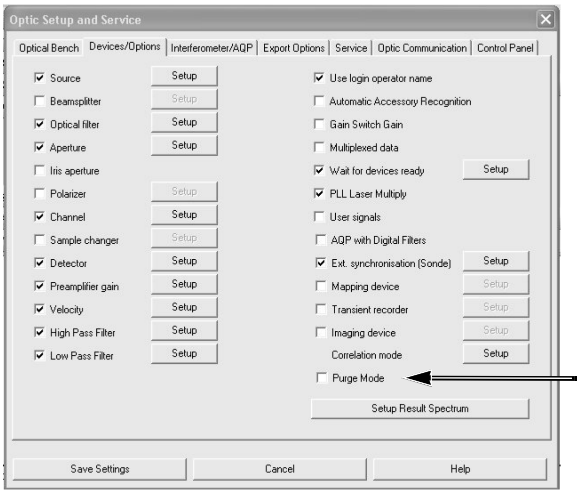


Figure 5.1: OPUS dialog - Optic Setup and Service

5.6.2 General information

The flaps as well as the venting and evacuating valves are controlled automatically via the OPUS software. So, evacuating and venting the sample compartment and/or optical bench is done by clicking on the corresponding buttons at the *Basic* page of the *Measurement* dialog window. See fig. 5.2.

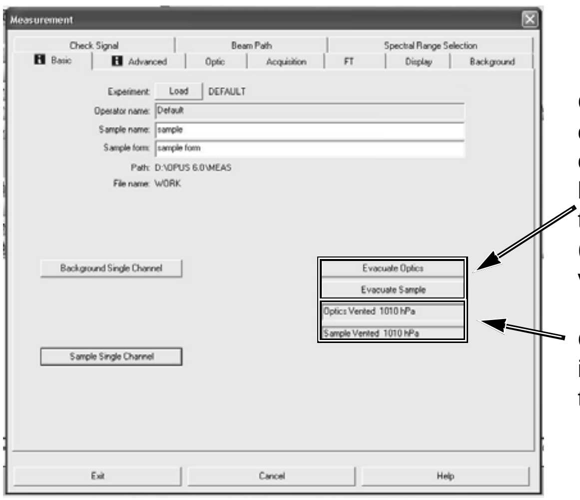


Figure 5.2: optical bench and sample compartment are vented.

To prevent OPUS from starting a measurement while the spectrometer is still being evacuated or vented proceed as follows: Click in the *Measurement* dialog window on the *Optic* tab and select in the *Optical bench ready* drop-down list the option *Pressure stable*. See fig. 5.3.

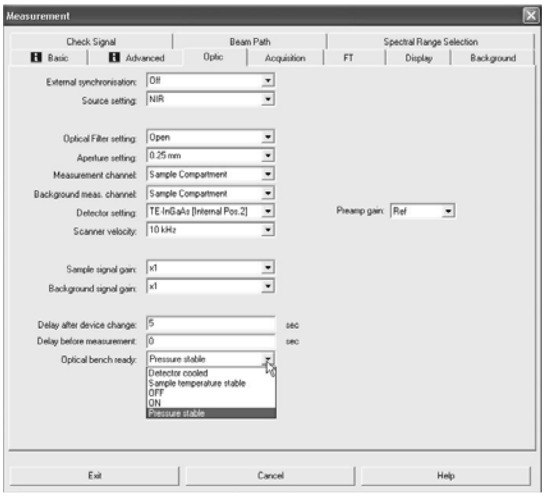
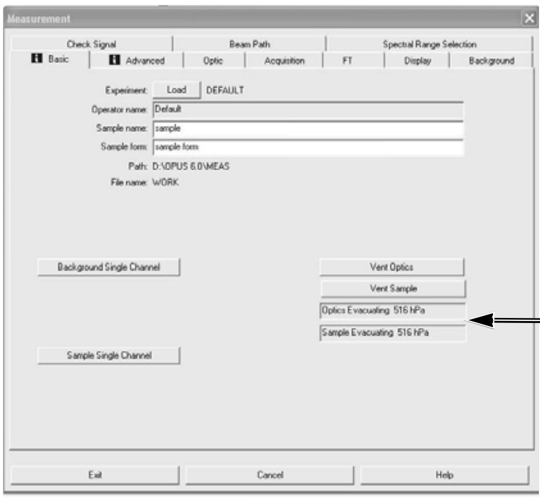


Figure 5.3: Defining a measurement start precondition

5.6.3 Evacuating

Let us assume the following initial situation: both the sample compartment and the optical bench are vented. In this case, it is **not** possible to evacuate either only the sample compartment or only the optical bench. So, clicking on either button effects the evacuation of both compartments.

The evacuation process is indicated by the messages *Optics Evacuating* and *Sample Evacuating* that appear in the fields below the buttons. The progress of the evacuation is shown by the permanently updated pressure readings in the lower fields. See fig 5.4.



Message indicating the running evacuation process and the current pressure reading

Figure 5.4: Optical bench and sample compartment are being evacuated.

As soon as the evacuation process is completed, the messages *Optics Evacuated* and *Sample Evacuated* appear in the lower fields. See fig. 5.5.

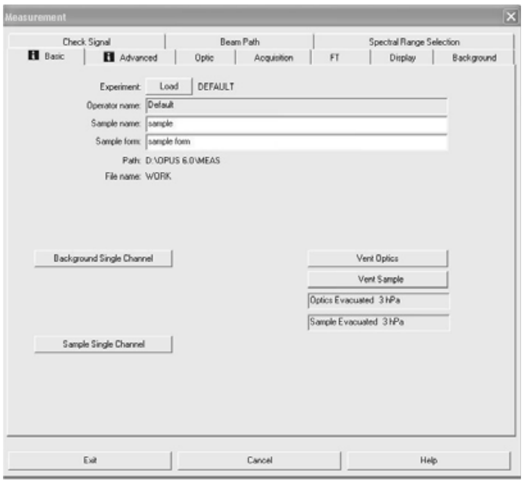


Figure 5.5: Optical bench and sample compartment are evacuated.

➣ **When the sample compartment is evacuated you cannot open it.**

5.6.4 Venting

When both compartments are evacuated you can vent the sample compartment separately (for example, if you want to open the sample compartment in order to exchange the sample) by clicking on the *Vent Sample* button.

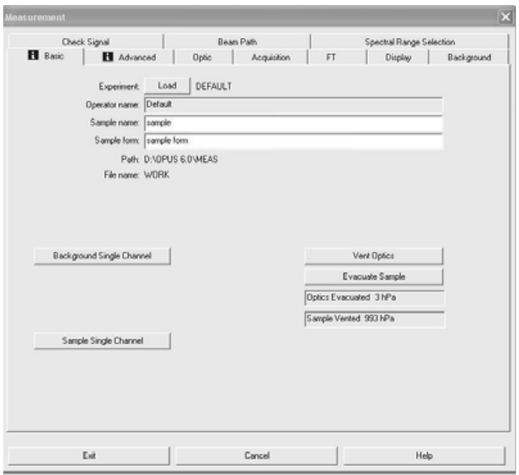


Figure 5.6: Optical bench is evacuated, sample compartment is vented.

When both compartments are evacuated, venting only the optical bench is **not** possible because the pressure ratio inside the spectrometer would damage the flaps. For safety reasons, the instrument does not perform this operation. In this case, clicking on the *Vent Optics* button effects the ventilation of the sample compartment as well. This precaution prevents the instrument from being operated wrongly.

5.7 Optimizing the vacuum

5.7.1 General information

To get optimum measurement results under vacuum conditions, there are some aspects that need to be taken into consideration:

- The thermal conditions in an evacuated optics bench and in a purged optics bench are completely different, i.e., under vacuum there is no thermal conduction at all due to the lack of the purge gas. This aspect has consequences on the reproducibility of the measurement results.
- Water molecules are very polar. Due to this property, they tend to stick at the inner wall of the optics compartment. For this reason, it takes time to get the water vapor pumped off completely.

The purpose of the following advice is to help you in achieving optimum measurement results.

5.7.2 Reproducibility of the measurement results

After you have evacuated the spectrometer, it is highly recommended that you allow the spectrometer to stabilize long enough. An optimally stabilized spectrometer is able to achieve an extreme high 100%-line stability in the sub-%-level with the standard optical components designed for MIR measurements. (Note: A precondition is that the room temperature does not vary by more than 1°C per hour and 2°C per day. Typically, this condition can be fulfilled in an air-conditioned environment.)

Recommendations:

- For demanding experiments, a stabilization period of at least 4 hours is recommended. After this period, the maximum instrument stability is achieved.
- For non demanding experiments, a stabilization time of 0.5 hour is sufficient.
- During a long-term experiment, it is recommended to repeat the background measurement in regular interval, at least every hour.
- Ideally, the spectrometer should be kept under vacuum overnight.

5.7.3 Residual water vapor

The following measures will further reduce the residual water vapor concentration inside the spectrometer:

- longer evacuation times
- a low dew point of the compressed air[1] (The compressed air should have a pressure dew point of at least -20°C; a pressure dew point of less than -50°C would be ideal. However, not the absolute dryness degree of the compressed air is of crucial importance but the long-term constancy regarding the dryness of the supplied compressed air.)

1. Note: Compressed air is required for the air bearing of the linear scanner.)

- ❑ Besides the necessity of a water vapor concentration being as low as possible, there is another aspect regarding water vapor you have to take into consideration: The water vapor line intensity in the sample spectrum does not depend on the absolute residual water vapor concentration in the spectrometer but on the different water vapor concentrations during the background and the sample measurement. Therefore, it is of crucial importance that the residual water vapor concentration is (nearly) identical during both the background measurement and the sample measurement.

5.7.4 Evacuation time

As mentioned above, water molecules are very polar. Due to this property, they tend to stick at the inner wall of the optics compartment, even under vacuum. For this reason, a long evacuation time is recommended. Ideally, the evacuation of the spectrometer should not be interrupted overnight. This action will further reduce the residual water vapor content.

5.7.5 Optimal evacuation procedure

Before acquiring a background spectrum, simulate a sample exchange in the same way as you will do it later for the "real" sample measurement:

1. Vent the sample compartment.
2. Afterwards, evacuate the sample compartment for about 3 to 5 minutes. (An evacuation time longer than 5 minutes is not necessary because after that period, the final pressure of < 3 hPa (< 3 mbar) will be achieved.)

➢ As soon as the final pressure is achieved, the message *Sample Evacuated* and the current pressure value are displayed in the *Measure* dialog window (fig. 5.7). The achievement of the final pressure is also indicated by the VACUUM LED at the spectrometer top side, i.e. this LED lights green. (See also section 4.1.2.)

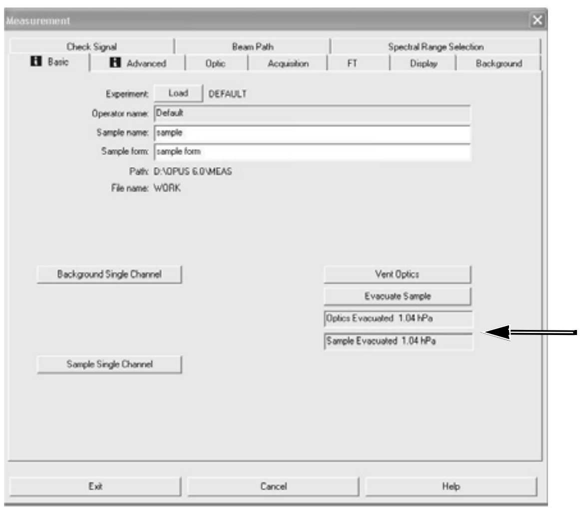


Figure 5.7: OPUS Measurement dialog - page *Basic*

➢ **Important:** The evacuation time before the background measurement and the evacuation time before the sample measurement have to be more or less identical. To ensure reproducible evacuation times, specify in OPUS a *Delay before Measurement*. See the fig. 5.8.

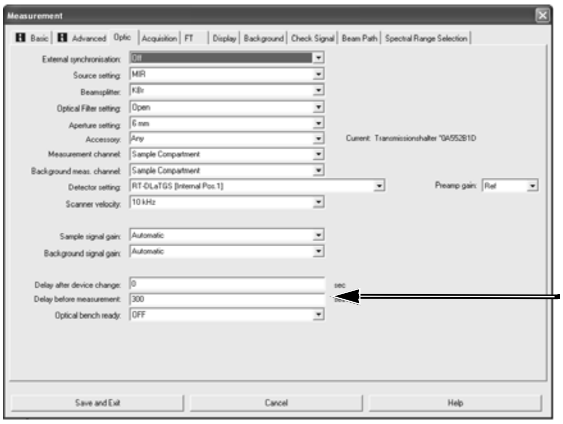


Figure 5.8: OPUS Measurement dialog - page *Optic*

3. Acquire a single channel background spectrum.
4. Afterwards, vent the sample compartment and place the sample in the sample compartment.
5. Evacuate sample compartment for about 3 to 5 minutes.
6. Acquire a single channel sample spectrum.

➢ Take into account that the intensity of the water vapor band in the sample spectrum does not depend on the absolute residual water vapor concentration but results from a water vapor concentration difference during the background and the sample measurement.

With the above described operation conditions and a spectral resolution of 4cm^{-1}, typically a residual water vapor band intensity in the range of significantly less than 0.1%T can be achieved.

5.8 Purging the spectrometer

5.8.1 General information

Purging the spectrometer is not necessarily required, especially when you perform measurements under vacuum. If, however, you do not perform the measurements under vacuum, purging is recommended, especially when you frequently open the compartment covers (e.g. due to a detector or beamsplitter replacement or a sample substitution) or if the ambient air humidity content is too high. In these cases purging reduces the level of water vapor, CO_2 or other components of the ambient air inside the spectrometer.

❑ Water vapor, CO_2 and other atmospheric contaminants cause unwanted absorption. For this reason, open the sample compartment, the detector compartment and/or the interferometer compartment only if it is really necessary in order to prevent water vapor, CO_2 or other contaminants from entering the above mentioned spectrometer compartments.

Purge gas requirements

Purge the spectrometer, for example, with dry air or low pressure nitrogen gas. The purge gas supply has to meet the following requirements:

- dry air or nitrogen gas (dew point < -40°C corresponds to a degree of dryness of 128ppm humidity)
- oil-free and dust-free
- min. pressure: 1 bar (14.5 psi)
- max. pressure: 2 bar (29 psi)
- initial purge gas flow rate should not exceed 500 liters/hour
- sustained purge gas flow rate should not exceed 200 liters/hour

DANGER

Risk of fire because of purging the spectrometer with a flammable gas

Non-observance of the following safety instructions could result in death or serious injury and major property damage.

➢ Do **not** feed **a flammable gas** into the spectrometer. Some spectrometer components become hot during operation. If a flammable gas comes in contact with a hot component, there will be the risk of fire.

➢ Purge the spectrometer only with dry air or nitrogen gas.

For information about how to connect the spectrometer to a purge gas supply line, see section 3.9.

Preparatory actions

➢ In case you use an "open" accessory (e.g. A480 Parallel Beam Unit), make sure that the purge gas inlet opening (B in fig. 5.9) in the sample compartment is open.

➢ In case you want to purge an "enclosed" accessory (e.g. micro ATR unit) you have to close the purge gas inlet opening in the sample compartment in order to ensure a sufficient purge of the accessory. Close the inlet opening (B in fig. 5.9) by screwing on the cap (C in fig. 5.9).

☞ **Attention:** For performing measurements under vacuum, do not forget to open the opening (B in fig. 5.9) again by removing this cap! Otherwise, the evacuation of sample compartment via the small purge gas inlet in the QuickLock locking mechanism (A in fig. 5.9) will take too long causing a red VACUUM LED after a certain period of time.

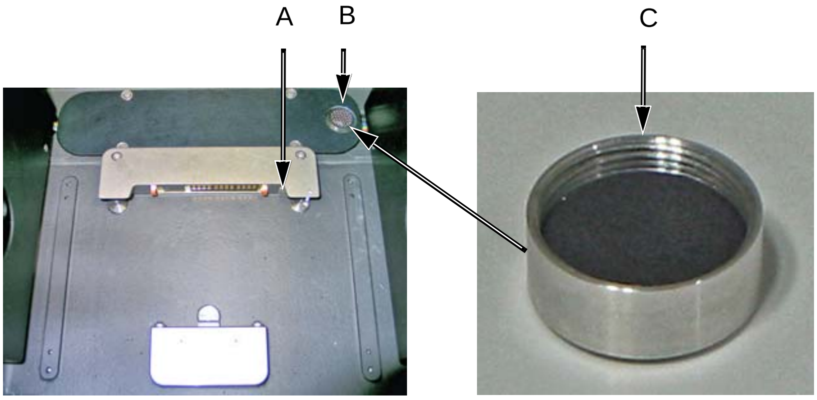


Figure 5.9: Purging the sample compartment

Figure 5.9	Component
A	Purge gas inlet opening for purging an enclosed accessory with a QuickLock baseplate
B	Opening for purging, venting and evacuating the sample compartment
C	Cap for closing the opening (B in fig. 5.9)

5.8.2 Activating the purge mode in OPUS

The spectrometer can be operated either in the vacuum mode or in the purge mode. To activate the purge mode, select in the OPUS *Measure* menu the *Optic Setup and Service* function. Click on the *Devices/Options* tab and make sure that the *Purge Mode* check box is activated. See fig. 5.10.

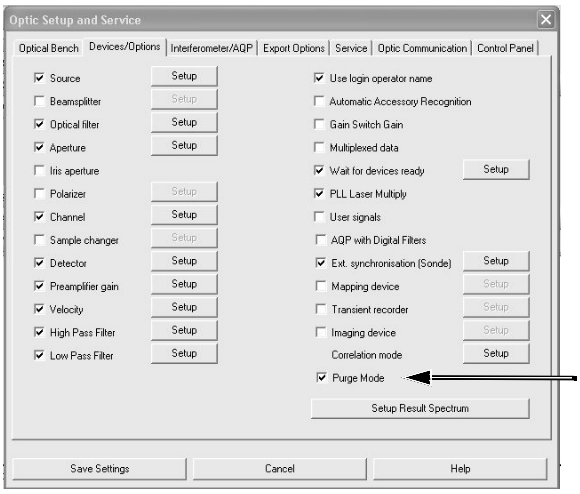


Figure 5.10: OPUS dialog - Optic Setup and Service

5.8.3 Controlling the flaps

The purge mode allows you to control (i.e. open and close) the flaps in order to purge either the sample compartment or the optical bench or both. The flaps are controlled via the OPUS software. The corresponding buttons are at the *Basic* page of the *Measurement* dialog window. See fig. 5.11.

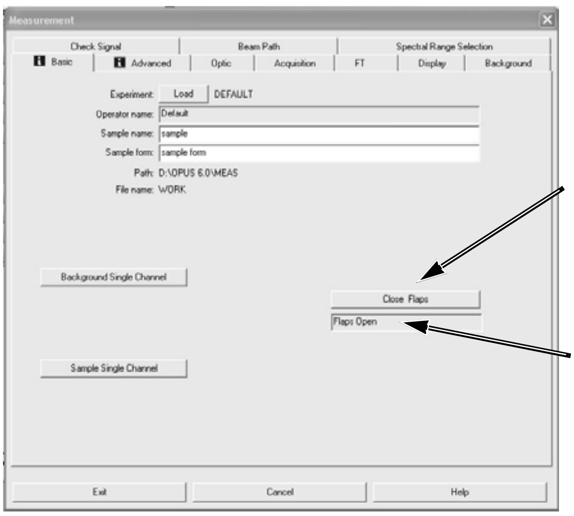


Figure 5.11: Controlling the flaps

❑ The flaps can be opened or closed only if the pressure difference between the sample compartment and the optical bench falls below the threshold value of 5 hPa.

5.8.4 Special case

Besides the normal purge mode in which the optical bench and/or the sample compartment are only purged, the following special case is also possible: the vented sample compartment is purged while the optical bench is evacuated.

For the realization of this special case, the spectrometer needs to be equipped with windows mounted on either the sample compartment walls or the flaps which are closed in this case. To realize this special case, proceed as follows:

1. Make sure that the vacuum mode is activated in OPUS. (See section 5.6.1.)
2. Evacuate the optical bench and the sample compartment. (See section 5.6.3.)
3. Afterwards, vent the sample compartment again. (See section 5.6.4.)

☞ In this condition, the flaps are closed.

4. Connect the purge gas inlet for the sample compartment (B in fig 3.3) to the local purge gas supply line using a hose. (See section 3.9.)
5. Now start the purge gas supply.

5.9 Extending the spectral range

5.9.1 General information

The spectral range in which the spectrometer is capable of detecting a signal is determined by the following optical spectrometer components:

- source,
- beamsplitter,
- sample compartment windows (if installed) and
- detector.

Consequently, extending the spectral range means the exchange of these spectrometer components. For information about how to substitute these optical components refer to the section 5.10, section 5.11 and section 5.12.

❏ After having replaced the one or more of the above listed optical components, it is highly recommended to validate the spectrometer performance by performing a PQ test using OVP. (See OPUS Reference Manual.)

5.9.2 Standard and optional spectral ranges

The standard spectrometer configuration is equipped for data acquisition in the mid IR region (8000 to 350 cm^{-1}). By exchanging the relevant optical components, the following optional spectral ranges are available:

• Far IR / THz:	680 to 5 cm^{-1}
• Near IR:	15,500 to 4,000 cm^{-1}
• Visible:	25,000 to 9,000 cm^{-1}
• Ultraviolet:	50,000 to 25,000 cm^{-1}

The spectral ranges of the available sources, beamsplitters, detectors and sample compartment windows are listed in section 4.2.2 (source), section 4.2.3 (detector), section 4.2.4 (beamsplitter) and section 4.2.7 (sample compartment window).

☞ **Make sure that the spectral ranges of the installed optical components correspond with each other!**

5.9.3 Automatic component recognition (ACR)

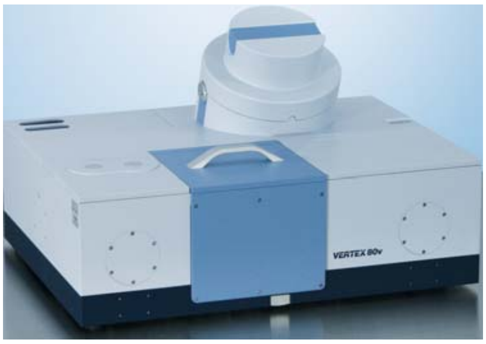
The optical spectrometer components source, beamsplitter and detector are electronically coded enabling the spectrometer firmware to recognize automatically the type of source, beamsplitter and detector that is actually installed. The information about the installed optical components is passed on to the spectroscopy software OPUS. This feature is called ACR (Automatic Component Recognition). Its purpose is to prevent you from selecting a wrong component in OPUS when you set up a measurement experiment. (Note: A wrongly selected component is indicated in OPUS by a red colored entry field of the corresponding drop-down list. See also the OPUS Reference Manual.)

5.10 Exchanging the beamsplitter

5.10.1 General information

The standard spectrometer configuration is equipped with a KBr beamsplitter for measurements in the mid-infrared region. In case your sample requires a different spectral range, the beamsplitter needs to be exchanged among other components. (See also section 5.9.)

In section 4.2.4, all available beamsplitters are listed including the spectral range they cover.

	In case of the **standard spectrometer design**, the beamsplitter is exchanged manually by the user. A precise locking mechanism fixes the beamsplitter automatically at its pre-aligned position. In this case, the optical bench needs to be vented first before you can exchange the beamsplitter. In the interferometer compartment, there are two beamsplitter storage positions and one beamsplitter operating position.
 	In case the spectrometer is equipped with the **optional automatic beamsplitter changer**, the beamsplitter exchange is fully software-controlled. In this case, the time-consuming venting and re-evacuating process is not required because the beamsplitter can be exchanged under vacuum. The automatic beamsplitter changer can be loaded with up to four beamsplitters. So, measurements in the complete spectral range can be performed without the need of venting the spectrometer, opening the optical bench and exchanging the beamsplitter by hand.

5.10.2 Handling instructions

NOTE

Irreversibly damaged beamsplitter because of improper handling

The beamsplitter is a very delicate component. Observe the following handling instructions to ensure a long service life.

- ➢ Do not touch the optical material of the beamsplitter as this can damage it irreversibly. Take hold of the beamsplitter only by the handle. (See fig. 5.12).
- ➢ The optical material of some beamsplitters are hygroscopic. Do NOT expose them to humidity or water vapor. Store the beamsplitter in a sealed container or in a dry environment (e.g. in the storage position inside the spectrometer, see E in fig. 4.4).
- ➢ Do not try to clean the optical material of the beamsplitter as this will definitively damage the beamsplitter irreversibly.
- ➢ Do not expose the beamsplitter (especially KBr beamsplitters) to temperature changes.
- ➢ Handle the beamsplitter with care. Avoid any kind of mechanical impact like stroke or falling down.
- ➢ Do not try to loosen or fasten the screws as this will impair the optical quality of the beamsplitter.

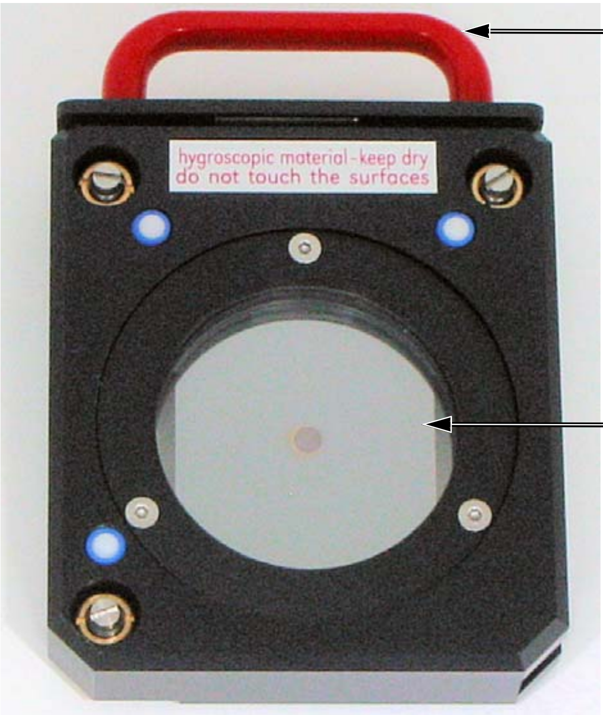
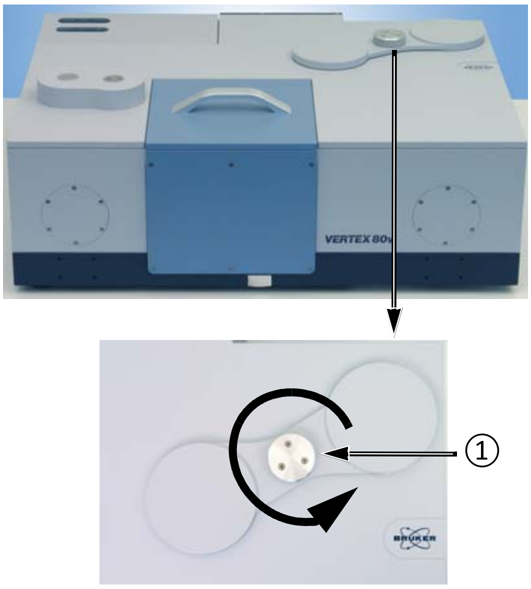
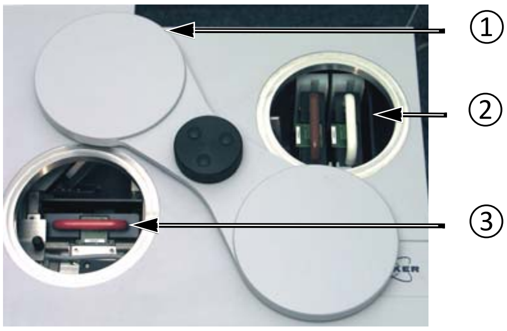
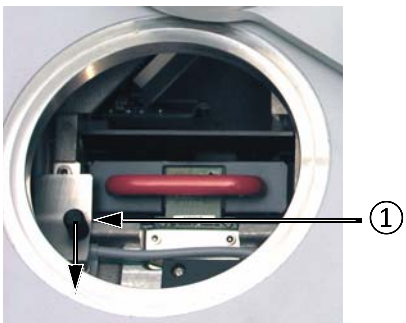
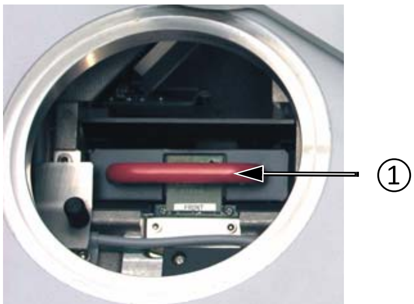
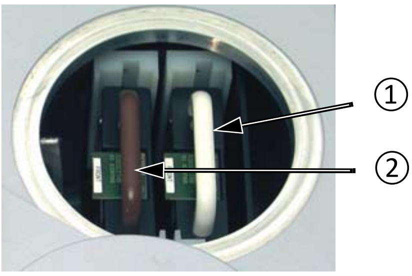
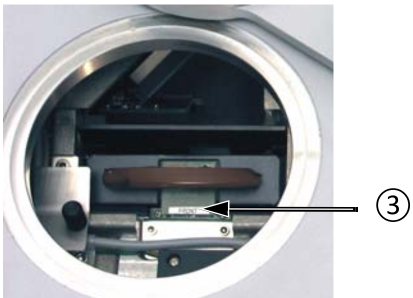
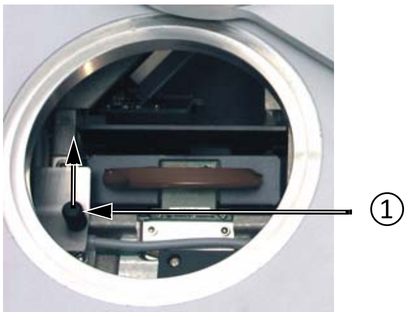
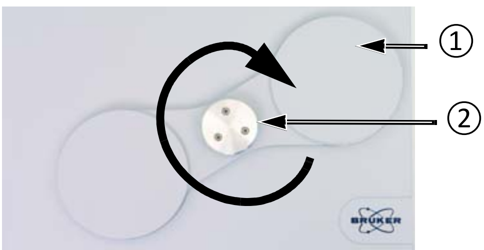


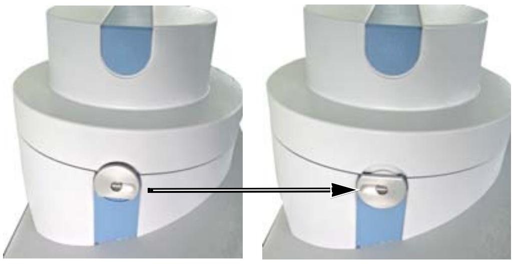
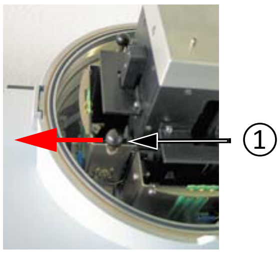
Figure 5.12: Beamsplitter

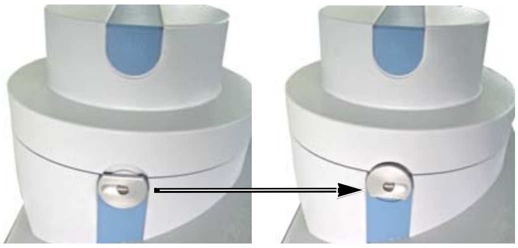
5.10.3 Manual beamsplitter exchange procedure

1	Vent the spectrometer, if not already done. (See section 5.6.4.)	
2		Turn the knob ① counter-clockwise until the stop.
3		Rotate the wing-shaped cover ① aside. Now you have access to the beamsplitter in operating position ③ as well as to the beamsplitters in the two storage positions ②. **Caution: When the wing-shaped cover is rotated aside, laser class 2 radiation is accessible. Do not stare into the beam! Risk of eye injury! An exposure time > 0.25 sec. will cause eye injury.**
4		Unlock the beamsplitter installed in the operating position by moving the release lever ① forward.

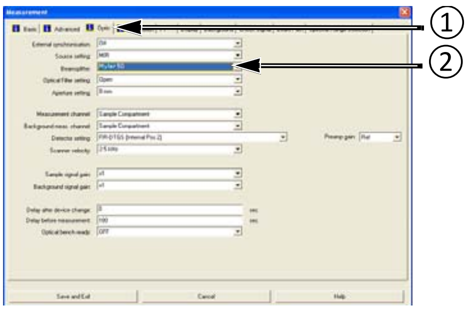
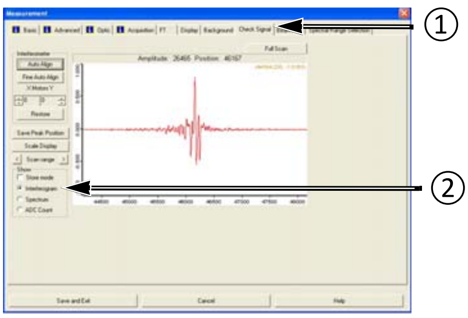
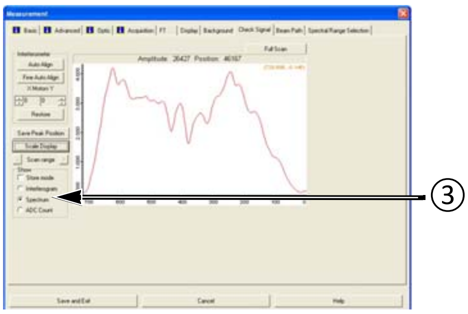
5		Take hold of the beamsplitter handle ① and pull the beamsplitter straight upwards without catching an edge.
6	 	Take the intended beamsplitter ① or ② out of the storage position holder. Insert the beamsplitter in the operating position holder with the electrical contacts facing to the spectrometer front side ③. Push down the beamsplitter completely until you feel resistance. **Attention!** Insert the beamsplitter carefully in the holder. Do not drop the beamsplitter in the holder. Hitting too hard on the ground will damage the beamsplitter.
7		Lock the beamsplitter by moving the release lever backward ①. ❏ A precise locking mechanism fixes the beamsplitter automatically at its pre-aligned position. ➢ A beep indicates that the beamsplitter has been recognized by the electronics. ➢ After a few seconds the spectrometer starts to scan.
8	Insert the beamsplitter, you have taken out of the operating position holder, either into the storage position holder or store it in the intended box.	
9		Rotate the wing-shaped cover ① over the openings and secure it by turning the knob ② clockwise.
10	Check whether a signal is detected and whether the signal intensity is OK. (See section 5.13.)	

5.10.4 Loading the automatic beamsplitter changer

1	Cover lock closed Cover lock open  	Remove the cover of the automatic beamsplitter changer. To do this, rotate the two locks at both sides of the cover half a turn. Lift off the cover.
2	  	Tilt the beamsplitter holder in the loading position using the knob ①. Insert the beamsplitter into the holder. Move the beamsplitter holder back to its normal position using the knob. ➣ The automatic beamsplitter changer can be loaded with up to four beamsplitters. The procedure is identical for all beamsplitters. **Important:** For inserting the fourth beamsplitter, the automatic beamsplitter changer needs to be rotated a quarter turn to move the fourth holder out of the operating position. (Note: With the holder being in the operating position, the beamsplitter cannot be inserted.) For information about how to operate the automatic beamsplitter changer, see section 5.10.5.

3	 Cover lock open Cover lock closed 	Reinstall the cover of the automatic beamsplitter changer by putting on the cover and ... ... turning the locks at both sides of the cover half a turn.

5.10.5 Software-controlled beamsplitter exchange procedure

1		In the OPUS *Measurement* dialog, open the *Optic* page ①. Select the desired beamsplitter in the *Beamsplitter* drop-down list ②. Note: the drop-down list includes all registered beamsplitters.
2	 	In the OPUS *Measurement* dialog, open the *Check Signal* page ①. Activate either the *Interferogram* option button ② or the *Spectrum* option button ③. ☞ As a result, the automatic beamsplitter changer moves the selected beamsplitter automatically in the operating position. ➢ Note: In case of a shifted interferometer peak position, save the new peak position as described in section 5.13.3.

5.11 Exchanging the detector

5.11.1 General information

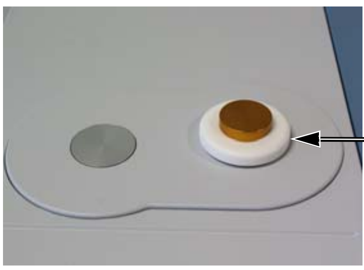
The standard spectrometer configuration is equipped with a DLaTGS detector with KBr window for measurements in the mid-infrared region. In addition, the detector compartment allows for mounting a second detector.

In case your measurement requires a different spectral range or another detector sensitivity, you can install another detector into the second detector position, which is an optional spectrometer feature, or exchange the installed DigiTect DLaTGS detector for another DigiTect detector, such as a MCT detector with a higher sensitivity or a NIR detector. In section 4.2.3, all available detectors are listed including the spectral range they cover.

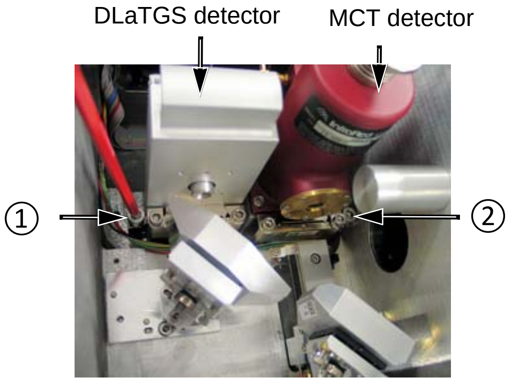
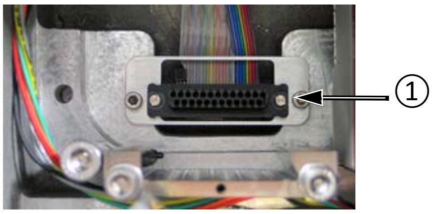
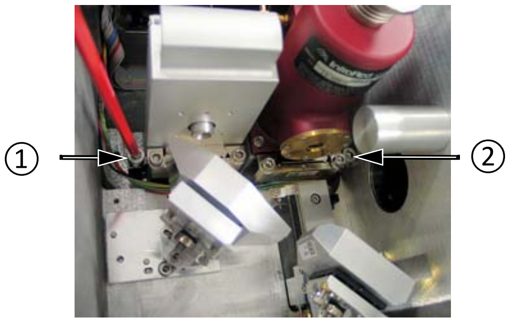
Make sure that the spectral range of the installed optical spectrometer components (source, beamsplitter, detector and sample compartment windows, if installed) correspond with each other! (See also section 5.9.)

5.11.2 Procedure

All available detectors are mounted on a dovetail slide which allows an easy exchange. A re-alignment is not necessary.

<table>
<tr><td>1</td><td colspan="2">Vent the spectrometer, if not already done. See section 5.6.4.</td></tr>
<tr><td>2</td><td>① 
 ②</td><td>Take off the detector compartment cover. ①

Caution: If there is a MCT detector installed in the detector compartment (including a vacuum-tight closure at the filling hole in the detector compartment cover), the detector compartment cover can not be taken off. Do not try to remove the cover forcibly as this may cause a spectrometer damage! In this case, first screw off the sealing adapter mating part ② before you take off the detector compartment cover. See section 5.14.3.</td></tr>
</table>

3		Loosen the locking screw (allen screw) that secures the detector using a hex key (size 6mm). Depending on which detector you want to remove, the allen screw is either on the left side of the detector ① or right side of the detector ②.
4		Pull the detector straight upwards out of the dovetail guide. **Caution:** Remove the detector carefully in order not to damage the detector and/or the mirrors.
5	 	Insert the other detector into the dovetail guide ① and push the detector downwards until you feel a resistance. ➢ A beep indicates that the detector has been recognized by the electronics. The electrical connections are established automatically.
6		Fasten the corresponding allen screw (① or ②) using a hex key (size 6mm).

7	① 	Place the cover on the detector compartment. Make sure that the four plastic pins in the corners at the bottom side of the detector compartment cover ① engage into the corresponding hole of the spectrometer case. Note: If there is a MCT detector in the detector compartment do not forget to reinstall the vacuum-tight closure at the filling hole in the detector compartment cover. See section 5.14.3.
8	Check whether a signal is detected and whether the signal intensity is sufficient. (See section 5.13.)	

5.12 Replacing a sample compartment window

5.12.1 General information

The windows are either flanged directly to the sample compartment walls or they are mounted on the flaps[1]. The precise replacement procedure depends on how the windows are mounted.

5.12.2 Handling instruction

NOTE

Irreversibly damaged sample compartment window because of improper handling

The sample compartment window is a delicate component. Observe the following handling instructions to ensure a long service life.

- ➢ The window is very fragile. Handle it with care. Avoid any mechanical impact.
- ➢ Do not touch the window surface. This may lead to irreversible contamination. (Note: Contaminations on the window surface can decrease the IR-transparency significantly.)

5.12.3 Safety note

Some sample compartment windows are of a material which is harmful or (very) toxic. (See section 4.2.7.) During normal spectrometer operation, these materials do not pose any health hazard. However, if such a window should break because of mechanical impact, be extremely careful.

WARNING

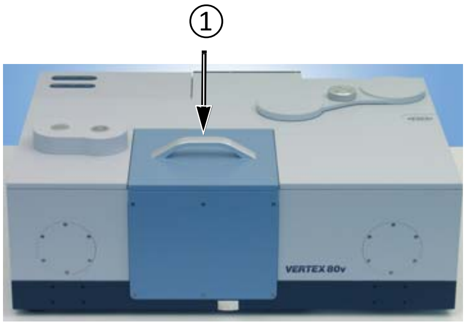
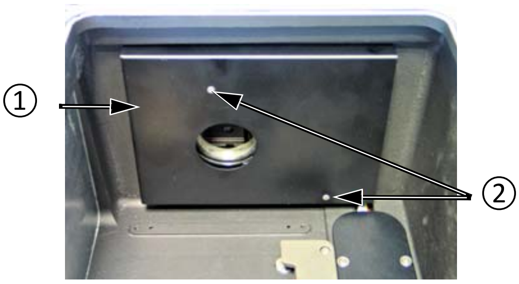
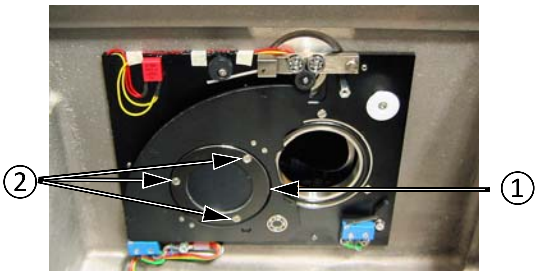
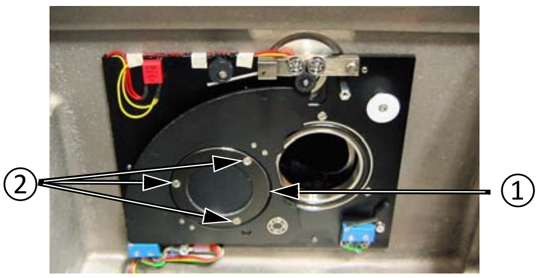
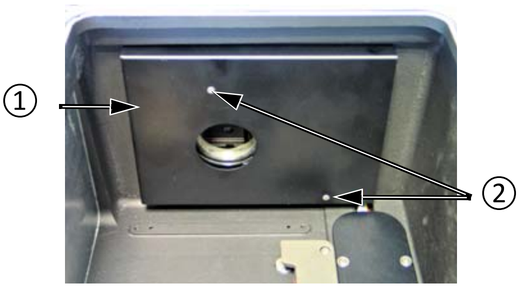
Health hazard because of improper handling of broken harmful or toxic window material

Non-observance of the following safety instructions could result in death or serious injury.

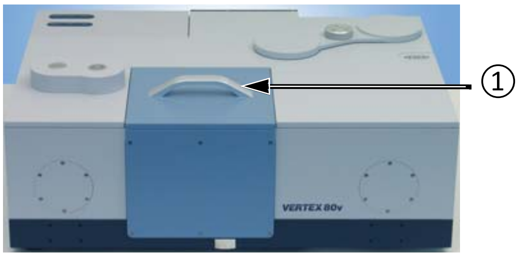
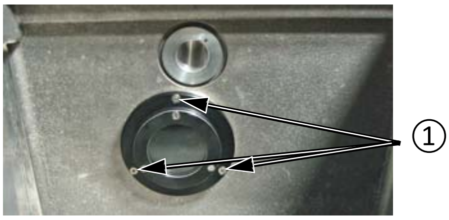
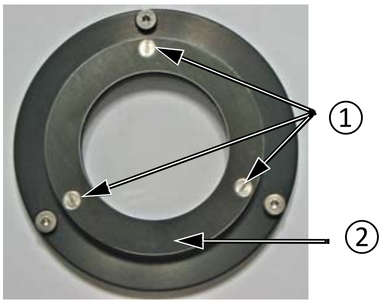
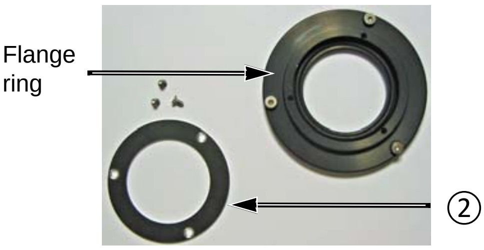
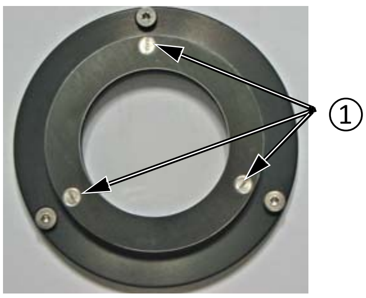
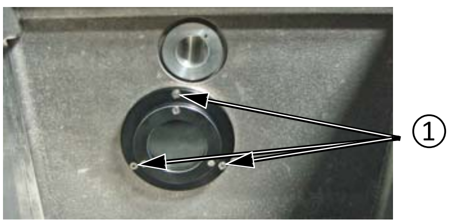
- ➢ Avoid generating dust of broken window material. This material is harmful or toxic if swallowed or inhaled.
- ➢ Also avoid skin and eye contact.
- ➢ Dispose the harmful or toxic material according to the laboratory regulations and the national regulations.
- ➢ Observe also the safety instructions of the attached safety data sheets.

1. The flaps are vacuum shutters. The purpose of the flaps is to provide an air-tight separation of the sample compartment from the optical bench in case you want to purge, evacuate or vent only either compartment. Note: Flaps are an optional spectrometer feature.

5.12.4 Replacement procedure for a window mounted on a flap

1		Open the sample compartment by taking off the cover ①.
2		To gain access to the flaps, remove the cover ① by loosening the two hex socket screws ② using a hex key (size 2mm).
3		Remove the window retaining ring ① by loosening the three slotted screws ②.
4	Take out the window and install a new one.	
5		Attach the window retaining ring ① by fastening the three slotted screws ②.
6		Reinstall the cover ① using the two hex socket screws ②.

5.12.5 Replacement procedure for a window flanged to the sample compartment wall

1		Open the sample compartment by taking off the cover ①.
2		Remove the complete window assembly by loosening the three hex socket screws ① using the hex key (size 2mm) ❑ The window assembly consists of the retaining ring, the window and the flange ring.
3		Loosen the three slotted screws ① and take off the retaining ring ②.
4	Take the window out of the flange ring and insert a new one.	
5		Reassemble the window assembly. ☞ Note: Tighten the slotted screws ① alternately.
6		Attach the reassembled window assembly to the sample compartment wall by fastening the three hex socket screws ① using the hex key (size 2mm)

5.13 Checking the signal

5.13.1 General information

Especially after you have replaced a spectrometer component (source, laser, beamsplitter, detector), it is advisable to check whether a signal is detected and to check whether the signal intensity (signal amplitude) is sufficient.

5.13.2 Procedure

1. Make sure that there is not any accessory and/or sample in the spectrometer sample compartment.
2. Open the software program OPUS.
3. Select in the *Measure* menu the *Advance Measurement* function.
4. Click in the *Measurement* dialog window on the *Check Signal* tab.
5. Make sure that the *Interferogram* option button is activated. (See fig. 5.13.)

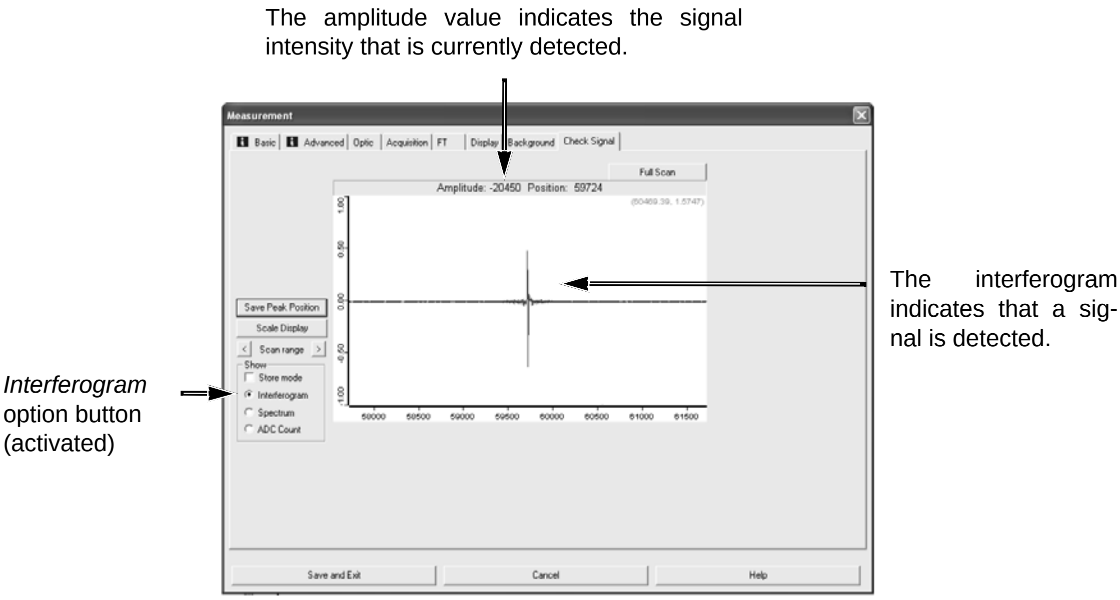


Figure 5.13: OPUS Dialog Window - *Measurement*

For verifying the currently detected signal intensity, compare the amplitude valve displayed in OPUS (fig. 5.13) with the amplitude value stated in the supplied OQ test protocol[1]. (See fig. 5.14.)

1. The supplied OQ test protocol documents the result of a factory-performed OQ test. The test has been performed with the spectrometer components being optimally adjusted. You will find the OQ test protocol in the folder supplied with the spectrometer.

Bruker OQ Test Protocol

Company:	Default
Operator:	Default
Instrument Type:	Vertex 80v Sample Compartment RT-DLaTGS
Optics Configuration:	Sample Compartment with: MIR, KBr, RT-DLaTGS [Internal Pos.1]
Accessory:	None
Instrument Serial Number:	2007891
Instrument Firmware Version:	1.510 Mar 7 2008
OPUS/DB Version:	20080204 / 6.5.6
Overall Test Result	PASS
Test expires:	2009/07/10 09:28:28
Test Date/Time:	2008/07/10 09:28:28
Test Spectra Path:	C:\Programme\OPUS_65\Validation\Data\20080710\092828
Comment:	

Resolution Test

Water Vapor Band:	1554.35 cm-1		
Maximum Resolution:	0.40 cm-1	Measured Resolution:	0.37 cm-1

Sensitivity Test

Measurement Region, Start:	2200.00 cm-1	Measurement Region, End:	2100.00 cm-1
Minimum S/N:	7000	Measured S/N:	9376.63

Energy Distribution Test

Minimum Energy Value:	0.10	Energy at 7500.00 cm-1	1.66
Minimum Energy Value:	0.20	Energy at 370.00 cm-1	0.95
Energy at 8000.00 cm-1	1.03	Energy at 350.00 cm-1	0.44

Wavenumber Accuracy Test

Expected Band:	1554.353 cm-1	Measured Band:	1554.354 cm-1
Maximum Deviation:	0.010 cm-1	Measured Deviation:	0.001 cm-1

Photometric Accuracy Test

Maximum Zero Crossing Value:	0.200%	Measured Value:	0.123%

Scan Time Test

Maximum Scan Time:	5.00 Sec	Measured Scan Time:	2.62 Sec

Alignment Test

Interferogram Peak Range:	62000 - 58000	Measured Peak Position:	59524
		Peak Amplitude:	-20732

Amplitude value

Figure 5.14: OQ- Test Protocol

If there is not any signal detected or if the amplitude value displayed in OPUS (fig. 5.13) deviates significantly from amplitude value of the supplied OQ test protocol (fig. 5.14) check the installation of the spectrometer component(s) you have replaced before. For troubleshooting, see also section 7.5.3.

5.13.3 Saving the interferogram peak position

General information

If the interferogram peak position has shifted in the course of time (i.e. it is no longer in the center of the display as shown in fig. 5.15), you have to save the new peak position.

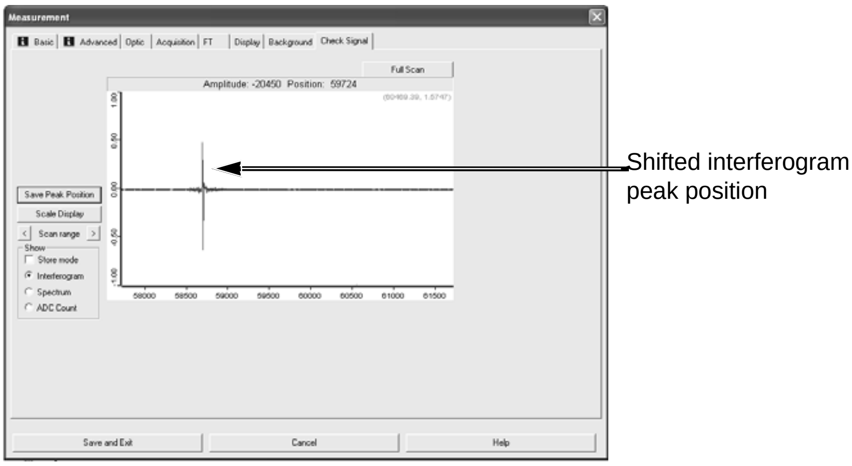


Figure 5.15: OPUS Measurement dialog - Check Signal dialog page

➢ Note: A shifted interferogram peak position is also indicated by the message *Peak Position out of range* in OPUS. This information message appears when you start a measurement with the interferogram peak position being shifted.

Procedure

1. Open the software program OPUS.
2. Select in the *Measure* menu the *Advance Measurement* function.
3. Click in the *Measurement* dialog window on the *Check Signal* tab.
4. Activate the *Interferogram* option button if it is not already activated.
5. Press the *Save Peak Position* button.
6. Exit the dialog.

➢ Note: When you reopen the *Check Signal* dialog page, the interferometer peak position is now in the center of the display.

5.14 Cooling the MCT detector

5.14.1 General information

For the spectrometer, several MCT detectors are available. See section 4.2.3.

The operating temperature of the MCT detectors is significantly below room temperature. To achieve the required operating temperature, the MCT detector needs to be cooled with liquid nitrogen, i.e. liquid nitrogen is filled in the MCT detector.

The hold time indicates how long the cooling effect of the liquid nitrogen lasts. To ensure an optimum signal detection, the MCT detector needs to be filled with liquid nitrogen in regular intervals. The available MCT detectors have different nominal hold times: 8, 12, or 24 hours.

Indications of a weakened or disappeared cooling effect are a low signal intensity or no signal detection. (See section 5.13.) In case no signal is detected, the OPUS status lamp turns to red. This problem is also indicated by the following instrument status message in OPUS: *Detector not ready.* See also section 7.2.3.

If the actual hold time of the MCT detector is considerably shorter than the nominal hold time, the MCT detector dewar needs to be evacuated. See section 6.3.

5.14.2 Safety notes

The temperature of liquid nitrogen is minus 196°C (minus 320.8°F).

⚠ CAUTION

Injury due to improper handling of liquid nitrogen

Non-observance of the following safety instructions may result in an injury.

- Risk of frostbites. Avoid skin contact. Handle liquid nitrogen always with care.
- Also the gases escaping from the liquid nitrogen are extremely cold and can cause frostbite. The delicate eye tissue can be damaged if exposed to this cold gas even for a short time. Protect your eyes by wearing a face shield or safety goggles! Note that goggles without side shields do not provide adequate protection!
- High nitrogen gas concentrations in an enclosed area can cause asphyxiation! Use liquid nitrogen only in well-ventilated areas. Nitrogen gas is colorless, odorless and tasteless. Therefore, it can not be detected by human senses and will be inhaled as if it were normal air.

5.14.3 Preparing the detector compartment cover

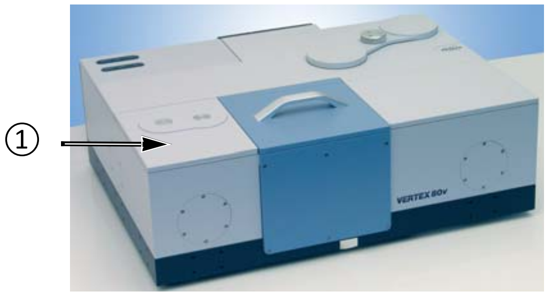
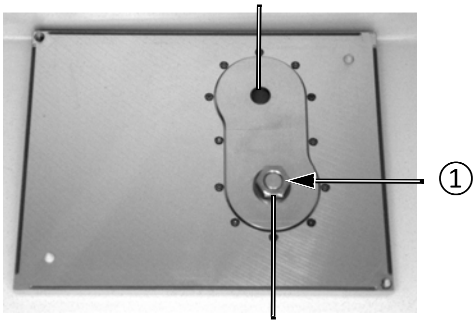
General information

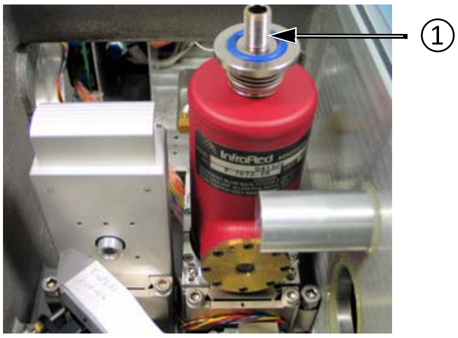
To fill the detector with liquid nitrogen you need neither to take the detector out of the spectrometer nor even open the detector compartment. A supplied funnel facilitates the filling in of liquid nitrogen in the MCT detector.

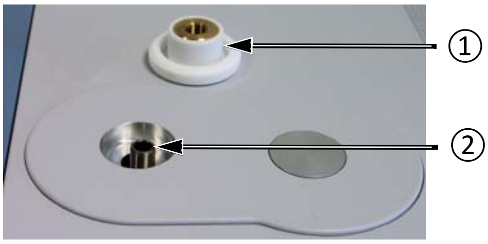
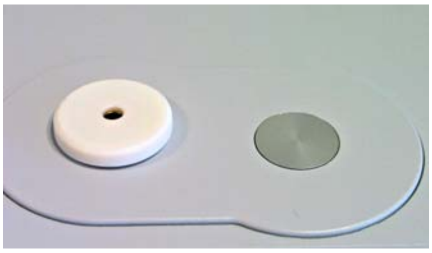
In case the MCT detector has been delivered together with the spectrometer, the detector compartment cover is already prepared for the funnel insertion. If the MCT detector has been ordered at a later date you need to prepare the cover as described below.

In accordance with the number of detectors that can be installed in the detector compartment of the spectrometer, there are two filling holes in the cover. These holes are intended to accommodate the funnel. (Note: The funnel is included in the delivery scope of the MCT detector.) Upon delivery, these holes are closed vacuum-tightly by a cap plus O-ring.

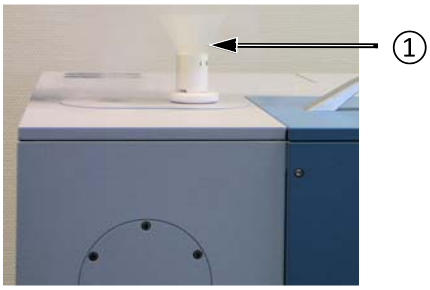
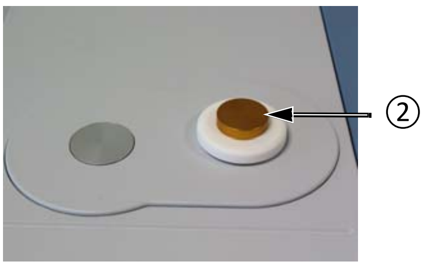
Procedure

<table>
<tr><td>1</td><td></td><td>Take off the detector compartment cover. ①.</td></tr>
<tr><td>2</td><td></td><td>Turn the detector compartment cover upside down and remove the cap from the filling hole that corresponds with the position of the MCT detector in the detector compartment. To do this, loosen the nut using a wrench (size 24mm). Remove the O-ring and the cap.</td></tr>
</table>

<table>
<tr><td>3</td><td></td><td>The MCT detector is delivered with a bellows-type sealing adapter ①. By default, the sealing adapter is factory-mounted.

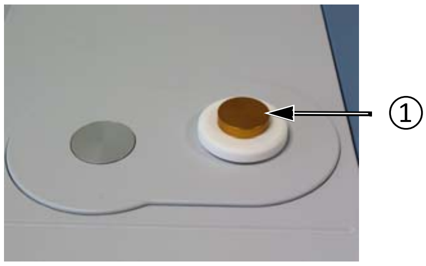
If not, screw the sealing adapter on the filling piece of the MCT detector.</td></tr>
<tr><td>4</td><td colspan="2">Place the cover on the detector compartment again. Make sure that the four plastic pins in the corners at the bottom side of the detector compartment cover engage into the corresponding hole of the spectrometer case.</td></tr>
<tr><td>5</td><td>
</td><td>Screw the sealing adapter mating part ① on the threaded end fitting of the sealing adapter ②.

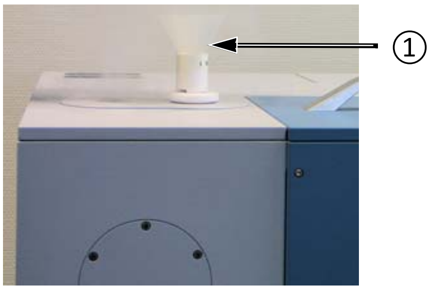
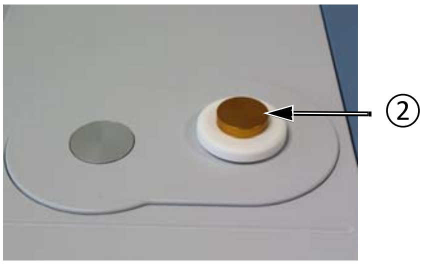
❏ When the spectrometer is evacuated, the sealing adapter and its mating part ensure a vacuum-tight closure at the filling hole in the detector compartment cover.

Notice: With the installed vacuum-tight closure at the filling hole, you cannot take off the detector compartment cover. In this case, do not try to remove the cover forcibly as this may damage the MCT detector! But first unscrew the sealing adapter.</td></tr>
<tr><td>6</td><td>
</td><td>For filling in liquid nitrogen, insert the funnel in the filling hole ①.

When not in use, close the filling hole with the supplied plug ②.</td></tr>
</table>

5.14.4 Filling the MCT detector with liquid nitrogen

1	 	Open the filling hole by removing the plug ①. Insert the funnel ② instead. ❏ The funnel is included in the delivery scope of the MCT detector.
2		Pour slowly liquid nitrogen in the funnel. Avoid spilling the liquid on the spectrometer housing. At first the liquid nitrogen evaporates and streams out again. Liquid nitrogen boils and splashes when it is filled a warm container. Especially at the beginning, when the temperature difference between the detector dewar and the liquid nitrogen is still very large, the liquid nitrogen may squirt out forcefully due to the boiling delay. Therefore, fill in the liquid nitrogen slowly to minimize boiling and splashing. **Stand clear of boiling and splashing liquid nitrogen and its issuing gas!** Be aware that during the entire filling process, liquid nitrogen can squirt out of the detector dewar from time to time. Wait until the funnel is empty before refilling. When the liquid nitrogen stops streaming out the detector dewar has reached liquid nitrogen temperature. Then, pour again liquid nitrogen in the funnel. Repeat this procedure until the detector has been filled to maximum. (As a rough rule of thumb for the standard MCT detector: the maximum capacity is about the quantity of two to three funnel fillings. Note that the first two funnel filling will evaporate almost completely.) **Avoid overfilling!** In this case the liquid flows out of the filling port.

3		After having filled in sufficient liquid nitrogen, remove the funnel (1) and insert the plug (2) instead.
4	➢ Wait about 20 minutes before starting a measurement to allow the detector to stabilize thermally.	

6 Repair and Maintenance

6.1 General information

The spectrometer is a low-maintenance instrument. For detailed information about how to maintain the vacuum pump, refer to the user manual provided by the vacuum pump manufacturer.

Only a few spectrometer components have a limited service life (e.g. laser, IR source). These components are easy to replace.

The following maintenance and repair works can be performed by the user:

- Restoring the MCT detector dewar vacuum
- Replacing the IR source
- Replacing the sample compartment windows
- Cleaning the spectrometer

Perform only those maintenance and repair works which are described in this manual. Adhere strictly to the described procedures and observe all relevant safety precautions. Otherwise, personal injury and/or spectrometer damage can be the result. In this case, Bruker does not assume any liability. Maintenance and repair works which are not described in this manual have to be performed by Bruker service personnel only. For the Bruker service contact data, see section 1.6.

NOTE

Damage to ESD-sensitive electronic spectrometer components because of accidental electrostatic discharges (ESD)

➢ Make sure that you are electrostatically discharged before you touch any electronic spectrometer component. Either use a grounded wrist strap or touch a grounded object (e.g. radiator). Note: The grounded wrist strap is the most effective (and the preferred) grounding method.

6.2 Performing an OQ test[1] using OVP[2]

After the replacement of a defective optical component[3] (source, beamsplitter or detector), it is highly recommended to perform an OQ test to ensure that the spectrometer achieves the specified parameter values[4]. (For detailed information about how to perform an OQ test refer to the OPUS Reference Manual.)

☞ The resolution test, which is part of the OQ test protocol, requires a gas cell filled with CO at low pressure. If you do not have such a gas cell at your disposal, contact the Bruker service. (See section 1.6.)

1. OQ test - Operational Qualification Test
2. OVP - OPUS Validation Program (It is intended for performing spectrometer validation tests like OQ and PQ.)
3. Perform the OQ test only after the replacement of a defective component, but NOT after exchanging an optical component for the purpose of extending the spectral range, for example.
4. In the course of the OQ test, the following parameters are tested: resolution, sensitivity, energy distribution, wavenumber accuracy, photometric accuracy, scan time, peak position and peak amplitude.

6.3 Restoring the detector dewar vacuum

6.3.1 General information

The operating temperature of the MCT detectors is significantly below room temperature. To achieve the required operating temperature, the MCT detectors are cooled down with liquid nitrogen. The available MCT detectors have different nominal hold times[1]: 8, 12 or 24 hours. To provide for the longest possible hold time, the MCT detector is integrated in a dewar. So, the actual hold time strongly depends on the quality of the vacuum in the detector dewar.

If the actual hold time decreases considerably with regard to the nominal hold time, the detector dewar vacuum needs to be restored. The existence of condensation water on the detector outside indicates that the vacuum must be stored soon. Another indication that a vacuum restoration is required is a failed *Ice Band Test*[2]. If the MCT detector outside is iced the detector dewar vacuum must be restored immediately.

Regarding the liquid-nitrogen-cooled detectors MCT with dewar, there are the following technical designs:

- The detector element is mounted in an evacuable dewar. In this case, the dewar vacuum is restored by evacuating the detector dewar with a vacuum pump. (See section 6.3.2.)
- In case of the PERMAVAC-type MCT detector, the dewar vacuum is regenerated. (See section 6.3.3.)

6.3.2 Evacuating the MCT detector dewar

Required evacuating equipment

- Vacuum pump (turbo molecular pump or oil-free high-vacuum pump that is capable of generating a vacuum of at least < 10^{-5}mbar)
- Adapter for connecting the vacuum pump to the MCT detector dewar
- Shut-off valve
- 2x flexible metal hoses

i The above listed evacuating equipment is NOT included in the standard delivery scope of the MCT detector. If desired, Bruker offers suitable evacuating equipment (part number S105-V2, D126 and I10290). Alternatively, Bruker also offers the service of evacuating the MCT detector dewar (part number SD128). This option requires the removal of the MCT detector from the spectrometer and the sending of the complete MCT detector to Bruker for evacuation.

1. The hold time indicates how long the cooling effect of the liquid nitrogen lasts.
2. The *Ice Band Test* checks whether there is a thin ice layer on the detector element. This in turn is an indication of the vacuum quality in the MCT detector dewar. The *Ice Band Test* is part of the PQ test protocol. For detailed information, refer to the OPUS Reference Manual.

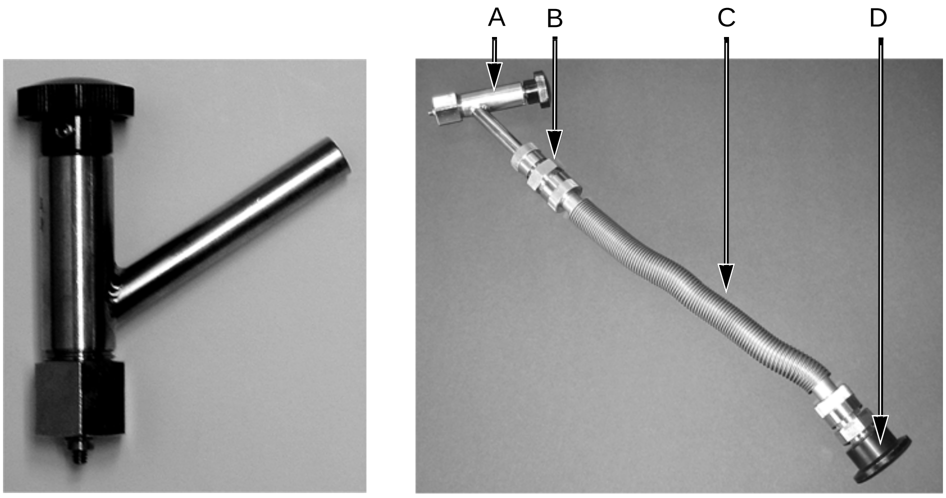


Figure 6.1: a) Adapter b) Adapter with flexible Metal Hose and Flange

Fig. 6.1	Component
A	Connecting adapter (for connecting the vacuum pump to the detector dewar)
B	Flange
C	Flexible metal hose
D	NW 25 flange (for connecting to the vacuum pump)

Procedure

☞ Before starting to evacuate the MCT detector dewar, make sure that the dewar does not contain any more liquid nitrogen and that the detector has warmed up to room temperature. Take into consideration that the detector warming-up from operating temperature to room temperature takes at least 3 hours after the residual liquid nitrogen has been emptied.

1. Remove the MCT detector from the spectrometer. See section 5.11.2.
2. Connect the adapter to the vacuum pump by flanging a flexible metal hose to the connecting piece of the adapter (E in fig. 6.3) and to the vacuum pump. See fig. 6.1b. (Note: The connecting piece of the adapter has an OD of 9.7mm.) In addition, install a shut-off valve between adapter and vacuum pump.
3. Make sure whether the shut-off valve is closed. Switch on the vacuum pump. Leave the pump running until it has reached its operating temperature.
4. Inspect the O-ring inside the adapter (C in fig. 6.3) for signs of wear.

☞ The O-ring inside the adapter is a wearing part that needs to be replaced after 4 or 5 evacuations at maximum.

5. Remove the cap from the connection nozzle of the detector. (See fig. 6.2a.)
6. Pull the adapter knob (G in fig. 6.3) to the open position and loosen the coupling nut (A in fig. 6.3).
7. Push the adapter carefully over the connection nozzle of detector dewar and fasten the coupling nut (A in fig. 6.3 hand-tight while holding the adapter and the detector as shown in fig. 6.2b. (A hand-tight tightening of the coupling nut is sufficient.)

☞ Hold the adapter and the detector always as shown in fig. 6.2b when you have to carry out the following tasks: opening and closing the evacuation valve by pushing or pulling the adapter knob (step 8, 12, 14 and 17), screwing the threaded adapter rod in or out of the connection thread of the dewar evacuation valve (step 11 and 15) and loosening the coupling nut (step 18).

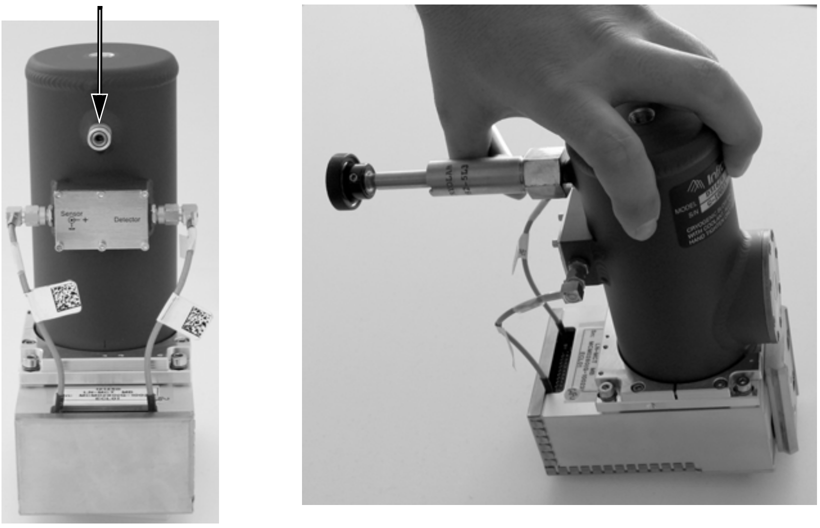


Figure 6.2: a) MCT detector b) How to hold the MCT detector when oping or closing the dewar evacuation valve

8. Push the adapter knob (G in fig. 6.3) in the closed position until the threaded rod (D in fig. 6.3) of the adapter is in contact with the sealing plug of the dewar evacuation valve.
9. Before you begin to evacuate the detector dewar, check the connections for leak tightness by evacuating the section between vacuum pump and detector at first. To do this, open the shut-off valve. If a vacuum of 10^{-4}mbar is generated within a few minutes it is an indication of the leak tightness of this section.
10. Close the shut-off valve again.
11. Screw the threaded rod of the adapter (D in fig. 6.3) in the connection thread of dewar evacuation valve by turning the adapter knob (G in fig. 6.3) clockwise; 2 to 3 rotations are sufficient. **Attention: In case of more than 2 or 3 knob rotations there is a risk that the threaded connection becomes inseparable! That means the threaded rod of the adapter cannot be screwed out of the connection thread of the dewar evacuation valve again.**
12. Pull the knob (G in fig. 6.3) to the open position in order to open the dewar evacuation valve.
13. Begin to evacuate the detector dewar by opening the shut-off valve.

☞ We recommend an evacuation time of at least 3 days to allow for generating an optimal vacuum inside the dewar. The final pressure in the detector dewar should be less than 10^{-5} mbar.

14. When the optimal vacuum is achieved, close the dewar evacuation valve by pushing the adapter knob (G in fig. 6.3) to the closed position. Press the adapter knob firmly to the stop position to ensure that the dewar evacuation valve is sealed airtightly.
15. Screw the threaded rod of the adapter (D in fig. 6.3) out of the connection thread of the dewar evacuation valve by rotating the adapter knob (G in fig. 6.3) several turns counterclockwise until you sense that the threaded adapter rod and the connection thread of the dewar evacuation valve are not joint any more. Be careful in order to prevent an unintentional opening of the evacuation valve and consequently to prevent the detector dewar from being vented again.
16. Vent the section between vacuum pump and adapter.
17. Pull the knob (G in fig. 6.3) to the open position. Attention: Make sure that the sealing plug of the evacuation valve is NOT pulled out! This may occur when you have screwed the threaded adapter rod too far in the connection thread of the dewar evacuation valve. (See step 10.) In this case repeat the dewar evacuation. If you do not succeed in closing the evacuation valve at all you have to send the detector in to Bruker.
18. Loosen the coupling nut (A in fig. 6.3) and remove the adapter from the connection nozzle of the detector dewar.
19. Reinstall the MCT detector in the spectrometer. See section 5.11.2.

☞ If a tiny amount of air should unawares get into the detector dewar during the evacuation procedure (e.g. when you close the evacuation valve) you can perform measurements with this MCT detector for the moment but after a relatively short period of time you have to repeat the detector evacuation.

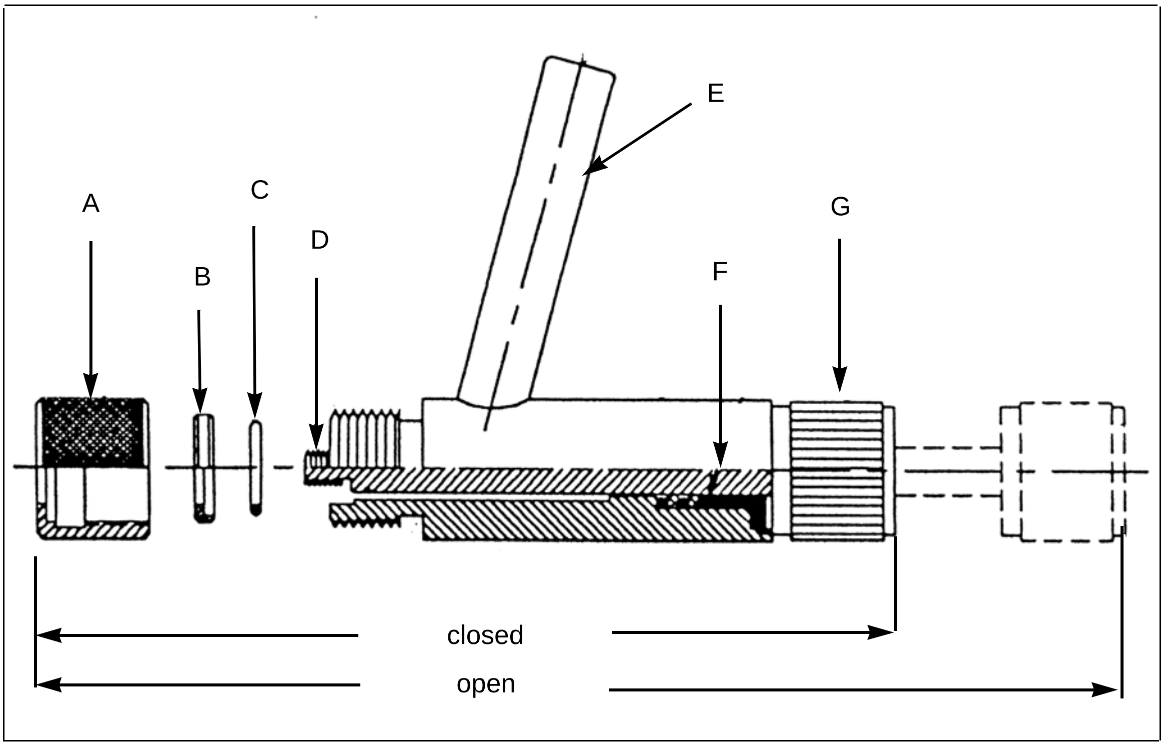


Figure 6.3: Connecting adapter - Cross section

Fig. 6.3	Components of the connecting adapter
A	Coupling nut
B	O-ring retainer
C	O-ring
D	Threaded rod (to remove the valve closure of the detector dewar)
E	Connecting piece for vacuum pump (OD = 9,7mm)
F	Washer and O-ring packing
G	Knob

6.3.3 Regenerating the vacuum of a PERMAVAC-type MCT detector

General information

In case of the PERMAVAC-type MCT detector, the dewar vacuum is regenerated. For the vacuum regeneration, the PERMAVAC-type MCT detector does not need to be removed from the spectrometer.

The vacuum regeneration is initiated by the user on the detector diagnostics page of the spectrometer firmware[1]. Once the user has initiated the vacuum regeneration process, it cannot be interrupted or stopped. The vacuum regeneration takes about 10 minutes.

Regenerating the dewar vacuum becomes necessary if the hold time[2] decreases significantly (i.e. a hold time of less than four hours). Another indication of a required vacuum restoration is a failed *Ice Band Test*[3].

NOTE
➣ The dewar vacuum can be regenerated only 5 to 6 times. For this reason, regenerate the detector dewar vacuum **only if it is really necessary!**
➣ If you are not absolutely sure whether the dewar vacuum needs to be regenerated contact the Bruker service. (See section 1.6.)

The anticipated vacuum regeneration interval is between 1.5 to 2 years. In case you intend to regenerate the dewar vacuum before the factory-defined minimum time period is elapsed, the following message is displayed on the Detector Diagnostics Page.

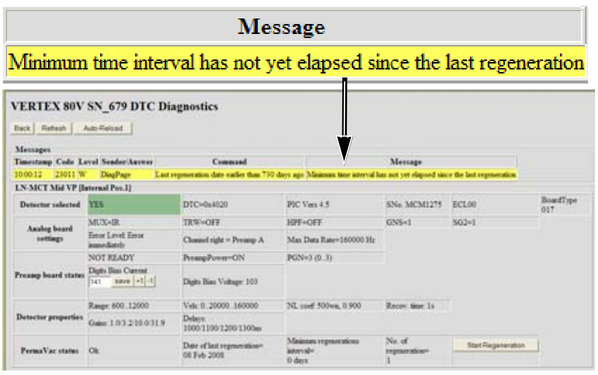
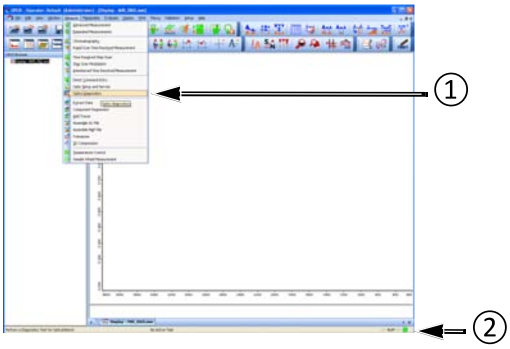
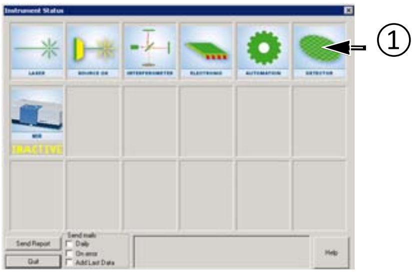
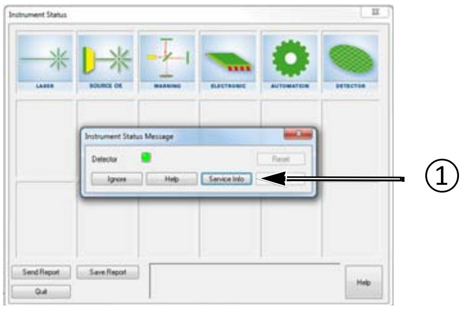
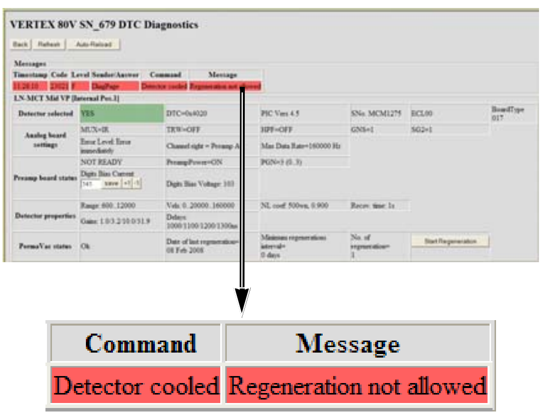


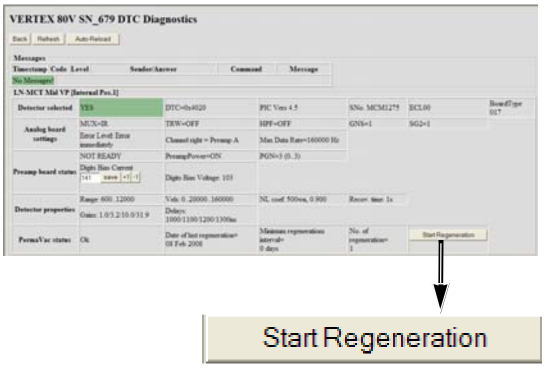
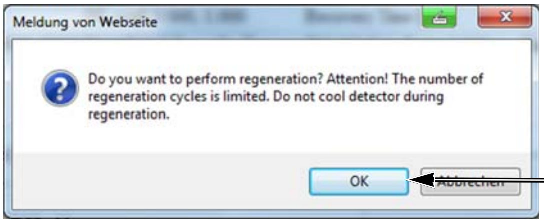
Figure 6.4: Detector Diagnostics Page

Note: Despite this message, you can initiate the vacuum regeneration as described in the following section.

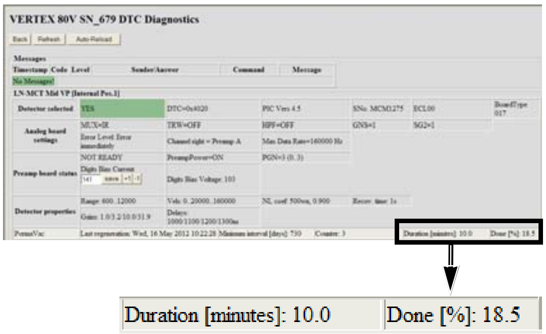
1. Diagnostics pages for relevant spectrometer components are provided by the spectrometer firmware. These pages contain all relevant information about the current operating state of the respective spectrometer component. For information about the diagnostics pages, see section 7.2.4.
2. The hold time indicates how long the cooling effect of the liquid nitrogen lasts. Note: The PERMAVAC-type MCT detector has a nominal hold time of ca. 8 hours.
3. The *Ice Band Test* checks whether there is a thin ice layer on the detector element. This in turn is an indication of the vacuum quality in the MCT detector dewar. The *Ice Band Test* is part of the PQ test protocol. For detailed information, refer to the OPUS Reference Manual.

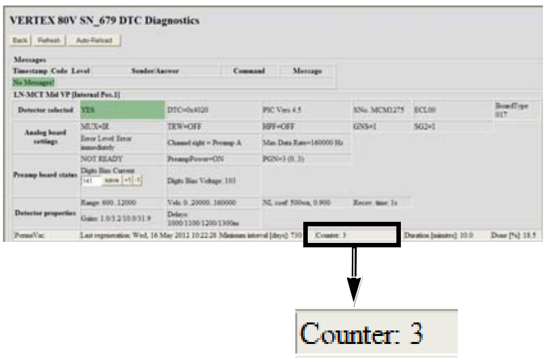
Procedure

1		Open the OPUS software program, if not already done. Either select in the OPUS *Measure* menu the *Optics Diagnostics* function ① or click on the OPUS status light ②. ➢ Thereupon, the *Instrument Status* dialog opens.
2		Click on the detector icon ①. ➢ Thereupon, the *Instrument Status Message* dialog opens.
3		Click on the *Service Info* button ①. ➢ Thereupon, the detector diagnostics page of the spectrometer firmware opens.
4		☞ **Important:** You cannot start the vacuum regeneration process, until the detector has warmed up to room temperature. As long as the detector has not yet warmed up, the message *Regeneration not allowed* is displayed on the Detector Diagnostics Page. In this case, you cannot initiate the vacuum regeneration. Wait until the detector has warmed up. Take into account that the detector warming-up from operating temperature to room temperature takes several hours.

<table>
<tr>
<td>5</td>
<td>
</td>
<td>Click on the Start regeneration button.</td>
</tr>
<tr>
<td>6</td>
<td>
</td>
<td>The following message appears.

Click on OK.

➢ Thereupon, the vacuum regeneration starts. Once the regeneration has been started, it cannot be stopped.</td>
</tr>
<tr>
<td>7</td>
<td>
</td>
<td>The vacuum regeneration process takes about 10 minutes.

The progress of the vacuum regeneration process is displayed at the Detector Diagnostics Page.</td>
</tr>
<tr>
<td>8</td>
<td>
</td>
<td>The counter shows how often the dewar vacuum has already been regenerated.

Note: The number of vacuum regeneration processes is limited!</td>
</tr>
</table>

6.4 Replacing a defective IR source

6.4.1 General information

The standard MIR source and the optional NIR source have a limited service life. When the end of the specified service life is nearly reached, the following message is displayed in OPUS: *End of average lifetime is nearly reached, spare part will be required*. When a source is defective, the following message is displayed in OPUS: *Source is broken or not connected*. (See also section 7.2.3.) In these cases, order a replacement source. For the order number, refer to appendix B.

6.4.2 Safety notes

⚠ CAUTION

Risk of skin burn

Non-observance of the following safety instructions may result in minor injury.

➢ Take into consideration that the IR source becomes very hot during operation. Do not touch a hot IR source.

➢ Wait until the IR source has cooled down sufficiently before you remove it.

6.4.3 Procedure

☞ The replacement procedure, as described in the following, is identical for both sources - the standard MIR source and the optional NIR source. Both sources are installed inside the spectrometer. See fig. 6.5

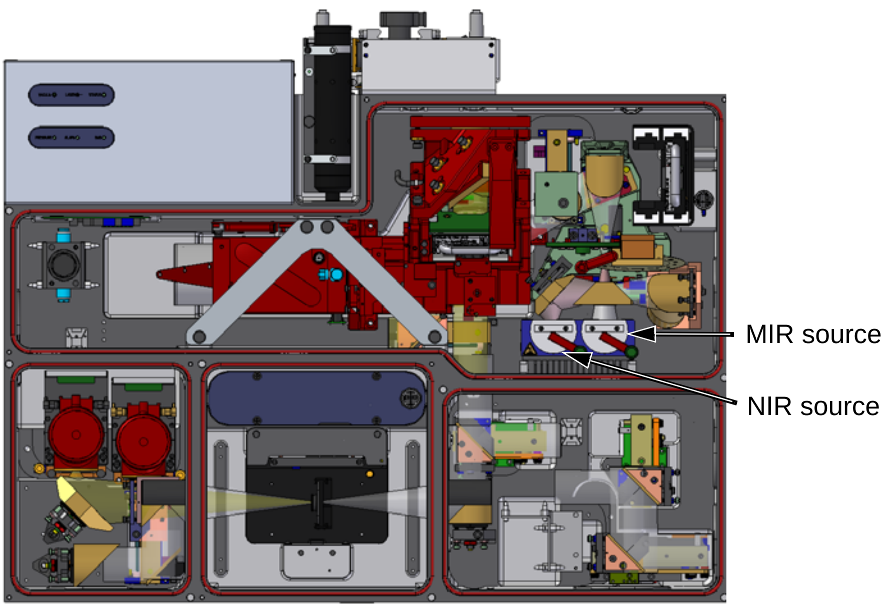
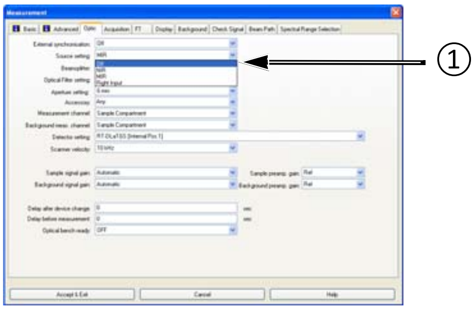
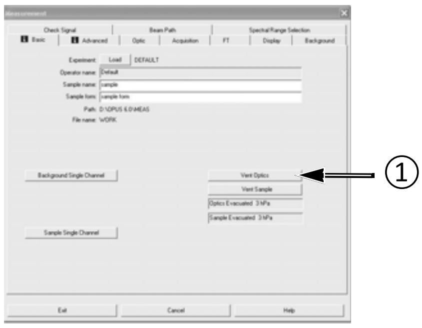
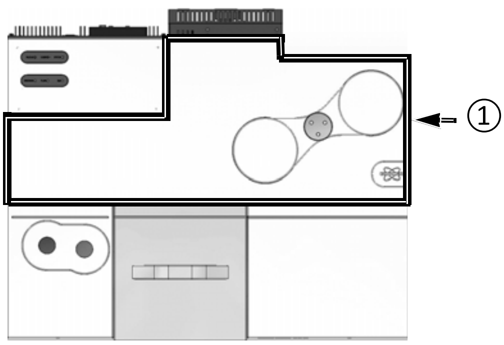
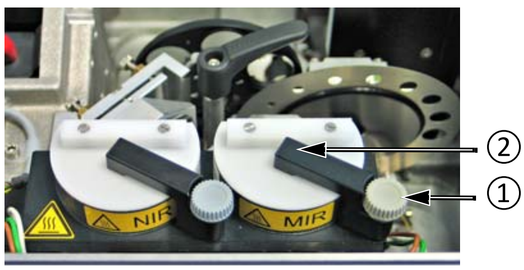
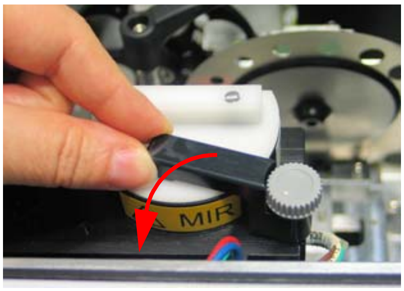
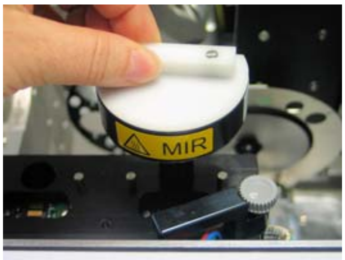
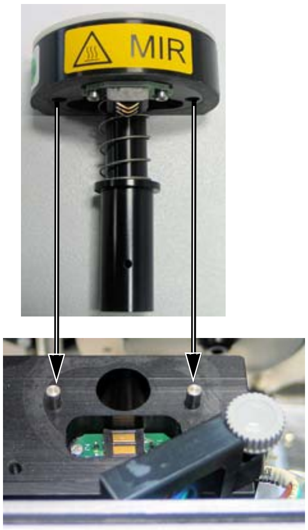
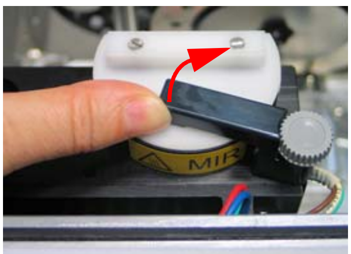
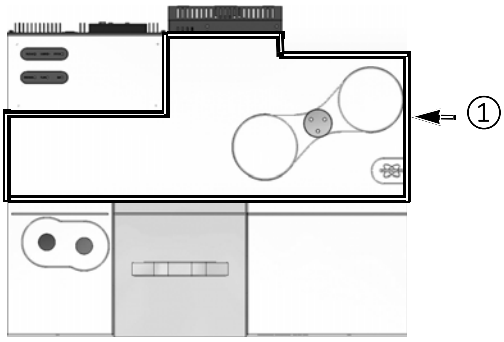
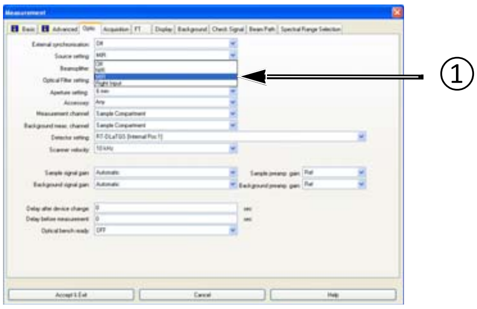


Figure 6.5: Location of the IR sources inside the spectrometer

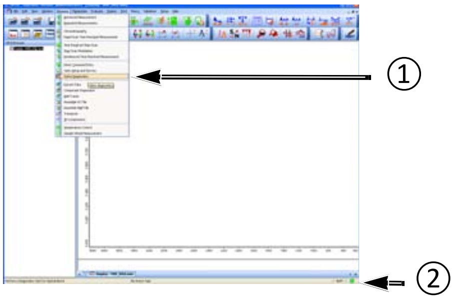
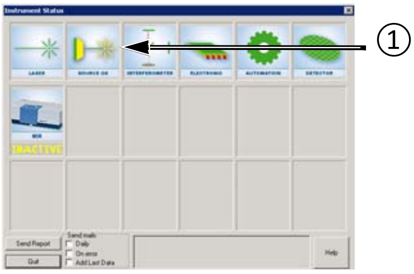
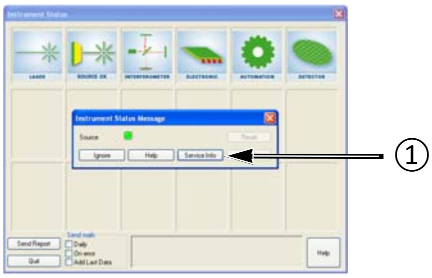
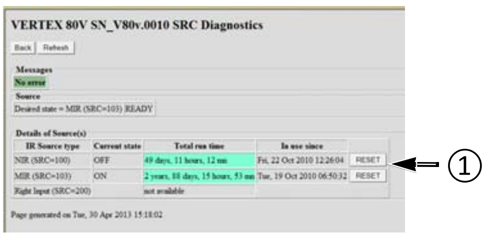
1		Switch off the source using the OPUS software program. To do this, select in the OPUS *Measure* menu the *Advanced Measurement* function. Open the *Optic* page of the *Measurement* dialog. Select in the *Source setting* drop-down list the option *Off* ①.
2		Vent the spectrometer, if not already done. To do this, click on the *Vent Optics* button ①. See also section 5.6.4.
3		Take off the interferometer compartment cover ①. **Caution: When the interferometer compartment is uncovered, laser class 2 radiation is accessible. Do not stare into the beam! Risk of eye injury! An exposure time > 0.25 sec. will cause eye injury.** **Caution:** Before you proceed with the next step, wait until the MIR source has cooled down sufficiently. **Do not touch a hot IR source! Risk of skin burn!**
4		Loosen the knurled thumb screw ① of the release lever ② (approx. one turn).

5		Press the source slightly downwards while swiveling the release lever aside.
6		Take out the source.
7		Insert the replacement MIR source into the seating hole. Note that the pins snap into the corresponding holes at the MIR source bottom side to ensure an exact source position.
8	 	Press the source downwards and ... ... swivel the release lever over the source to secure it. ➣ A beep indicates that the source has been recognized by the spectrometer electronics.

9		Tighten the knurled thumb screw ① of the release lever.
10		Close the interferometer compartment by placing the cover ① on it.
11		Switch on the source using the OPUS software program. To do this, select in the OPUS *Measure* menu the *Advanced Measurement* function. Open the *Optic* page of the *Measurement* dialog. Select in the *Source setting* drop-down list the option *MIR* ① or *NIR*.
12	Reset the source operating hours counter. (See section 6.4.4.)	
13	Check whether a signal is detected and whether the signal intensity is sufficient. (See section 5.13.)	
14	Perform an OQ test. (See also section 6.2. For detailed information about how to perform an OQ test refer to the OPUS Reference Manual.) ☞ If the OQ test fails, see section 7.5.4 for troubleshooting.	

6.4.4 Resetting the source operating hours counter

After having replaced the source, do not forget to reset the source operating hours counter. To do this, proceed as follows:

1		Open the OPUS software program, if not already done. Either select in the OPUS *Measure* menu the *Optics Diagnostics* function ① or click on the OPUS status light ②. ➢ Thereupon, the *Instrument Status* dialog opens.
2		Click on the source icon ①. ➢ Thereupon, the *Instrument Status Message* dialog opens.
3		Click on the *Service Info* button ①. ➢ The source diagnostics page of the spectrometer firmware opens.
4		Click on the RESET button ① of the source in question.

6.5 Replacing a broken or opaque sample compartment window

In case a sample compartment window has got broken or its opaqueness has reached such a degree that the transparency (infrared transmittance) is seriously reduced, it needs to be replaced. For detailed information about how to replace a sample compartment window, see section 5.12.

☞ When installing a new sample compartment window, make sure that its transmission range corresponds with the spectral range of the other installed spectrometer components: source, beamsplitter and detector. (See also section 5.9.)

6.6 Cleaning the spectrometer

If required, you can clean the outer spectrometer housing with a dry or damp cloth.

NOTE

Spectrometer damage because of improper cleaning

➢ Do not use detergents with organic solvents, acid or base!

➢ Do not clean the spectrometer interior. This may lead to serious spectrometer damage.

➢ Do not rub dirt or dust particles off a mirror surface, not even with a lens cloth or a lens tissue! Otherwise, the mirror will be damaged irreversibly. Blow off dust particles on the mirror surface using compressed air, for example. In case you do not succeed in blowing off the dirt, contact the Bruker service. (See section 1.6.)

7 Troubleshooting

7.1 General information

This chapter deals mainly with the most common spectrometer problems that may occur as experience has shown. It provides information about possible causes of the problem and presents solutions for troubleshooting. If the solutions listed in this chapter do not eliminate your spectrometer fault contact the Bruker service. For the Bruker service contact data refer to section 1.6.

Depending on how a spectrometer problem becomes apparent, they are divided in the following categories:

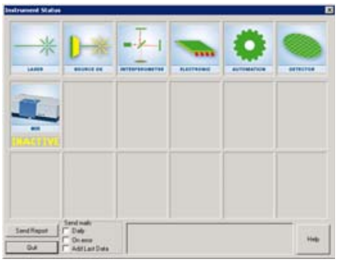
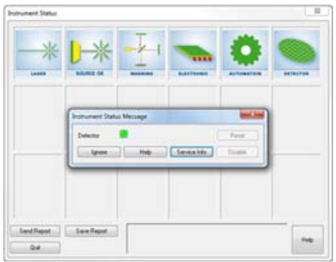
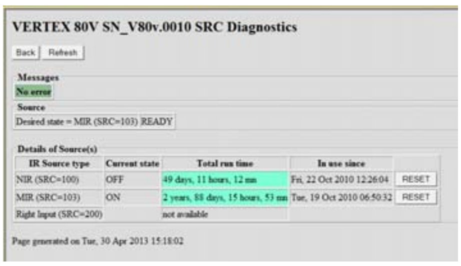
- Spectrometer problem indicated by a red LED of the status indicator board
- Spectrometer problem indicated by an instrument status message in OPUS
- Spectrometer problem indicated by one of the various diagnostic LEDs at the spectrometer rear side (e.g. ERR LED, voltage status LEDs)
- No communication between spectrometer and computer
- A signal check in OPUS reveals that no signal is detected or that the signal intensity is too low.
- A failed validation test (e.g. PQ test)

The available diagnostic means (e.g. spectrometer status indicator board, instrument status messages in OPUS, diagnostics pages of the spectrometer firmware) enable the operator to identify many spectrometer problems, or at least to narrow down a problem. (The available diagnostic means are described in detail in section 7.2.) In addition, there is the possibility of a remote fault diagnosis by the Bruker service. See section 7.4.

Due to easy-to-replace spectrometer components, the operator can solve many problems himself. The holders and/or locking mechanisms for the spectrometer components source, beamsplitter and detector ensure a correct installation position of these components, i.e. after the replacement of these components, a realignment is not required.

7.2 Diagnostic means

For a spectrometer fault diagnosis, the following diagnostic means are at your disposal:

	Status indicator board on the spectrometer top side (See section 7.2.1.)
	OPUS dialog window *Instrument Status* (See section 7.2.2.)
	Instrument status messages in OPUS (See section 7.2.3.)
	Diagnostics pages of the spectrometer firmware (See section 7.2.4.)
	Several diagnostic LEDs at the spectrometer rear side (See section 7.2.5.)

7.2.1 Status indicator board

The color in which the six status indicator board LEDs light up gives a general indication of the operating status of the corresponding spectrometer component. For detailed information about the status indicator board, see section 4.1.2.

☞ **Basically, a red status indicator board LED indicates a spectrometer problem.**

VACUUM

A red VACUUM LED indicates the following problem: When the spectrometer is being evacuated, but a certain threshold pressure value is not reached within a certain period of time (i.e. the ultimate vacuum is not achieved). See section 7.5.1.1 for troubleshooting.

LASER

Normally, a red LASER LED indicates a laser problem, for example:

- Laser power is too weak or
- Laser beam is blocked or
- Laser module is defective or
- Laser module is out of alignment.

See section 7.5.1.2 for troubleshooting.

➢ **Important note:** This LED also lights up red during the spectrometer initialization phase. **In this case, there is not any laser problem.** After the spectrometer initialization is completed successfully, this LED turns automatically to green.

STATUS

Normally, a red STATUS LED indicates a spectrometer problem. See section 7.5.1.3 for troubleshooting.

➢ **Important note:** This LED also lights up red during the spectrometer initialization phase. **In this case, there is not any laser problem.** After the spectrometer initialization is completed successfully, this LED turns automatically to green.

PRESSURE

A red PRESSURE LED indicates that there is not sufficient air pressure for the air bearing of the linear scanner. In this case, measuring is not possible. See section 7.5.1.4 for troubleshooting.

FLAPS

A red FLAPS LED indicates a flap malfunction or an error regarding the flaps. See section 7.5.1.5 for troubleshooting.

Note: The flaps are vacuum shutters. They are an optional spectrometer feature.

BMS

A red BMS LED indicates a beamsplitter problem, for example:

- There is not any beamsplitter installed in the operating position.
- The beamsplitter is not installed properly (i.e. it is not locked).

See section 7.5.1.6 for troubleshooting.

7.2.2 OPUS dialog *Instrument Status*

The OPUS dialog window *Instrument Status* allows you to diagnose which spectrometer component has caused the failure or to find out whether an OVP test has expired or failed. To perform a fault diagnosis, proceed as follows:

1. Either click on the OPUS status light or select in the OPUS *Measure* menu the *Optics Diagnostics* function. The following dialog window opens:

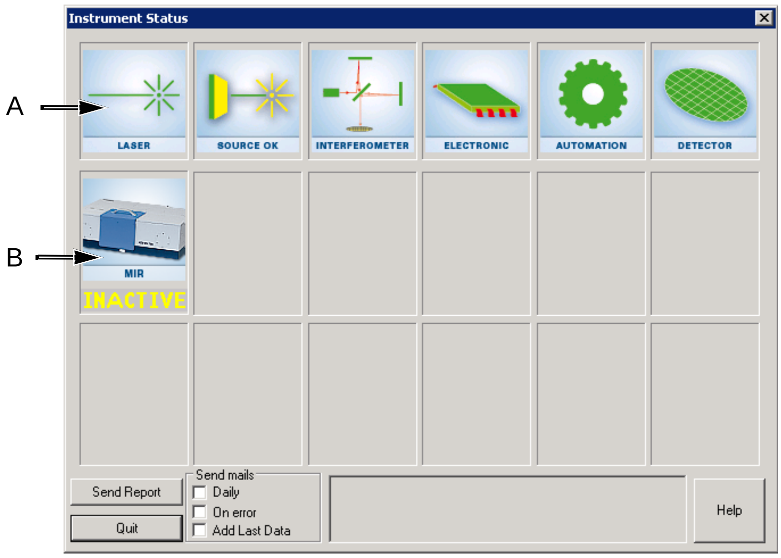
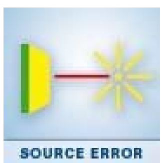


Figure 7.1: Optics Diagnostics - Instrument Status dialog

A) The status of the hardware components, e.g. source, laser, interferometer etc. is displayed in the upper icon line. The status can be as follows:

	**OK** Component is okay.
	**WARNING** The exact meaning of a warning depends on the component in question. For example, in case of the source, a warning means: • End of the specified lifetime of the component is nearly reached. In this case, measuring is still possible.
	**ERROR** Component is defective. In this case, measuring is no longer possible.

B) The second row of icons refer to the possible active test channel and indicates the result of the last OVP[1] test performed. The results can be as follows:

	**INACTIVE (yellow):** The single tests of the particular test category are disabled.
	**PASSED (green):** OVP test passed. Test is still valid.
	**EXPIRED (light blue):** The validity period of an OVP test has expired. What to do in this case? Perform the OVP test in question. (See OPUS Reference Manual.)
	**FAILED (red):** OVP test failed. What to do in this case? Try to find out the cause of a failed OVP test by performing a systematic fault diagnosis. (See section 7.3 and section 7.5.4.) Solve the problem. Then repeat the OVP test in question.

2. To perform a fault diagnosis of a particular spectrometer component click on the respective icon in the first row of the *Instrument Status* dialog. The *Instrument Status Message* dialog opens. (See fig. 7.2.)

1. "Validation test" is a collective term for all tests (e.g. OQ - Operational Qualification, PQ - Performance Qualification) that can be performed with OVP in order to validate the spectrometer. OVP (OPUS Validation Program) is part of OPUS. The general purpose of these validation tests is to check whether the spectrometer system achieves the specified performance or not. For information about OVP refer to the OPUS Reference Manual.

7.2.3 Instrument status messages in OPUS

Some spectrometer problems are indicated additionally by a corresponding instrument status message displayed in OPUS. ((See fig. 7.2.) These messages appear when you click on the icon of the optical component in question in the *Instrument Status* dialog.

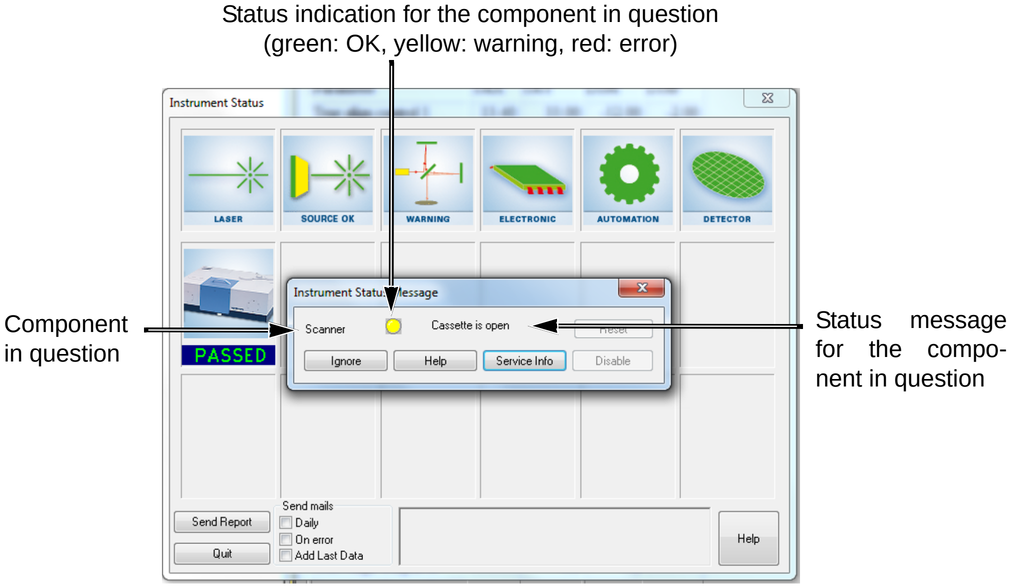


Figure 7.2: Instrument status message in OPUS indicating a scanner problem

7.2.4 Diagnostic pages of the spectrometer firmware

When you click on the *Service Info* button (see fig. 7.2), the diagnostics page for the component in question opens. The diagnostics pages of the spectrometer firmware contain all relevant information about the current operating state of the respective spectrometer component. In the following figures, the information relevant to fault diagnostics are highlighted by a rectangle.

The following figures (fig.7.3 to fig. 7.8) show the diagnostics pages of the following spectrometer components:

- Laser (HeNe-Laser Diagnostics Page)
- Source (SCR Diagnostics)
- Interferometer (Scanner Diagnostics)
- Detector (DTC Diagnostics)
- Electronic (Instrument Ready Diagnostics)
- Automation (Automation units Diagnostics)

➢ The explanation of the diagnostic pages is restricted to the most important pieces of information which are relevant to the user for troubleshooting.

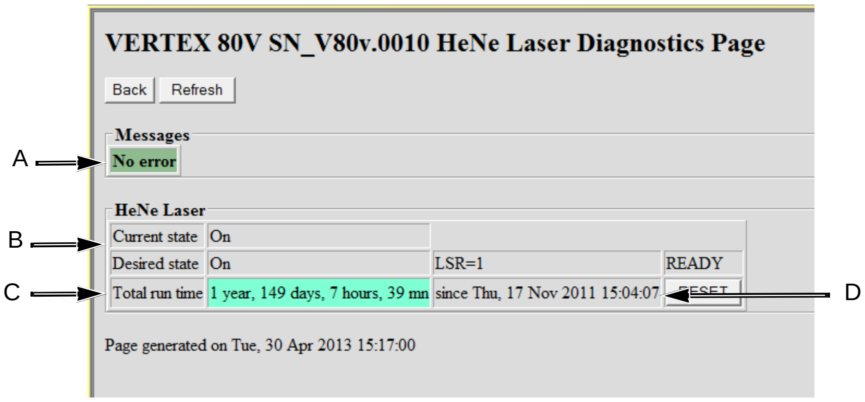


Figure 7.3: Laser diagnostics page

Fig. 7.3	Explanation
A	Possible error message Note: They are identical to the instrument status message in OPUS.
B	Current state: Current switch state of the laser Desired state: State selected by user
C	Total run time: Current reading of the laser operating hours counter
D	Date of putting the laser into operation for the first time

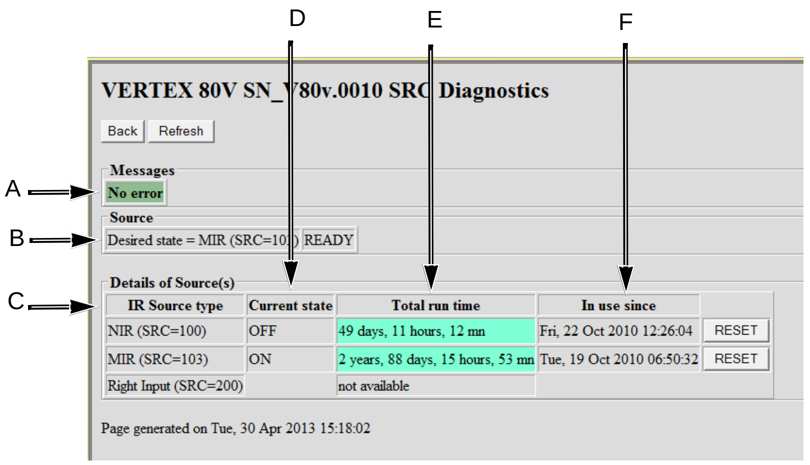


Figure 7.4: Source diagnostics page

Fig. 7.4	Explanation
A	Possible error message Note: They are identical to the instrument status message in OPUS.
B	Desired state: State selected by user
C	IR source type: Currently installed source(s) are listed
D	Current state: Current switch state of the source(s)
E	Total run time: Current reading of the source operating hours counter(s)
F	In use since: Date of putting the source in question into operation for the first time

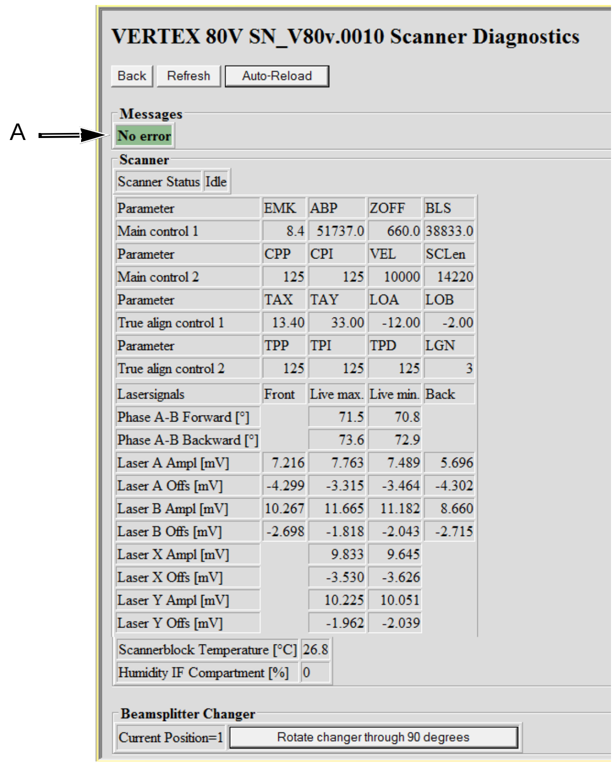


Figure 7.5: Scanner (Interferometer) diagnostics page

Fig. 7.5	Explanation
A	Possible error message Note: They are identical to the instrument status message in OPUS.

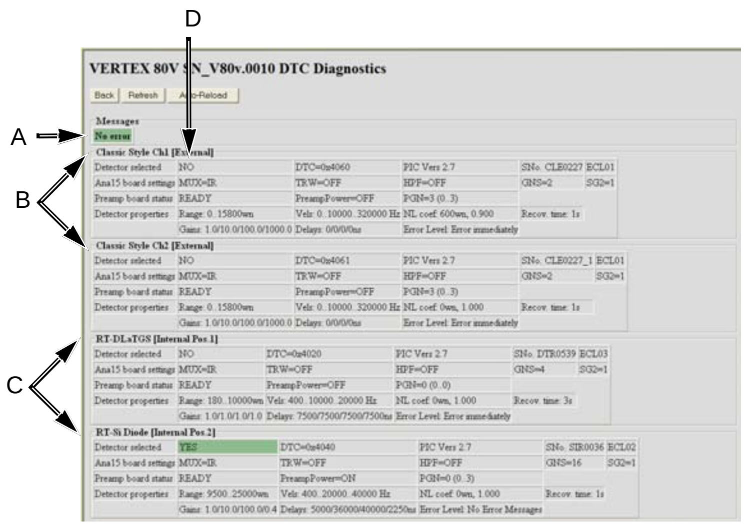


Figure 7.6: Detector diagnostics page

Fig. 7.6	Explanation
A	Possible error message Note: They are identical to the instrument status message in OPUS.
B	Channels for possible externally connected detectors
C	Internally installed detectors
D	Detector selected: (YES or NO): status of the current selection Note: The detector is selected in OPUS by the user.

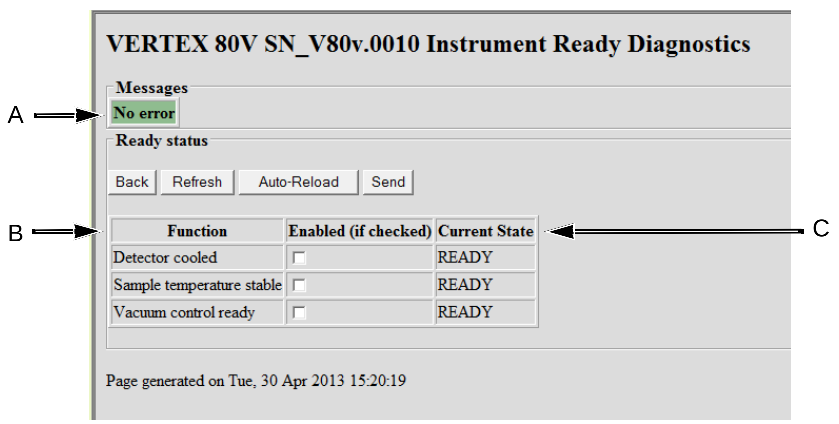


Figure 7.7: Electronics diagnostics page

Fig. 7.7	Explanation
A	Possible error message Note: They are identical to the instrument status message in OPUS.
B	Function: Parameters which define the readiness of the spectrometer to measure
C	Current state: Current switch state of readiness of the parameters in question

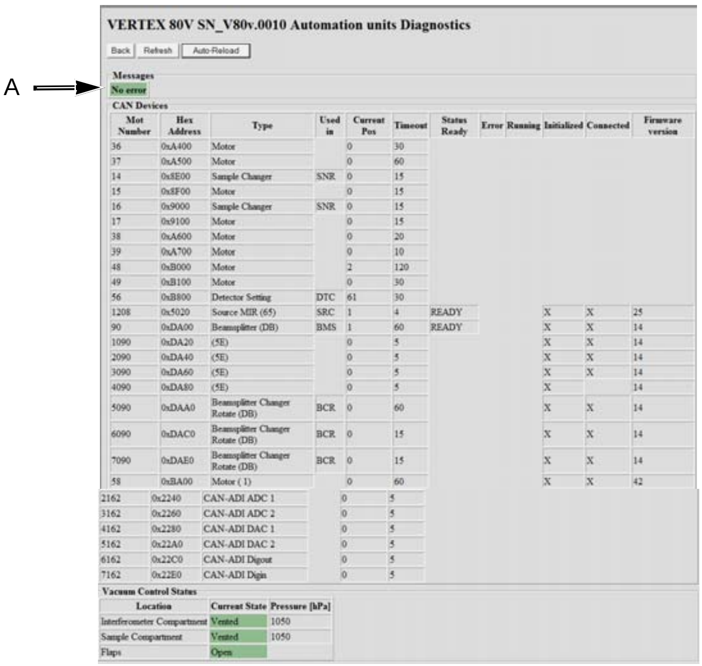


Figure 7.8: Automation units diagnostics page

Fig. 7.8	Explanation
A	Possible error message Note: They are identical to the instrument status message in OPUS.

7.2.5 Diagnostic LEDs at the spectrometer rear side

At the spectrometer rear side, there are the following diagnostic LEDs:

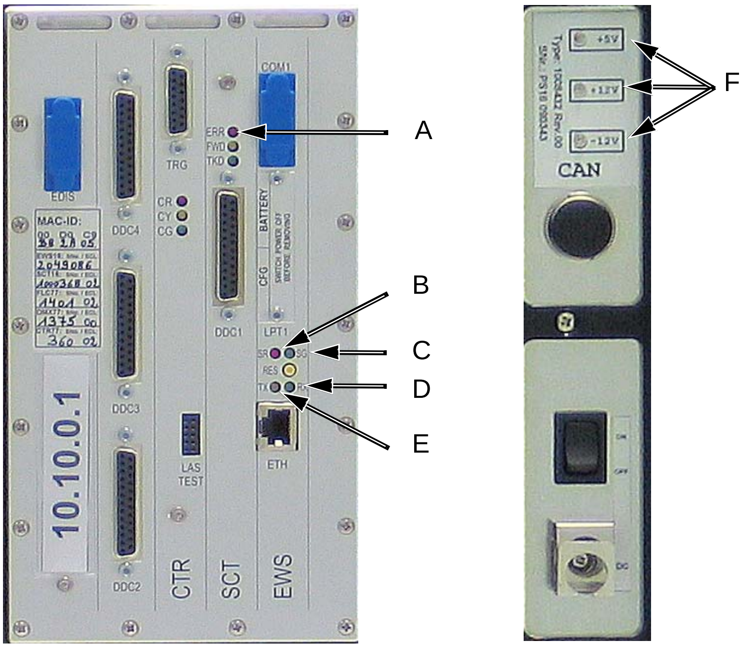


Figure 7.9: Rear side of the electronics compartment (detail views)

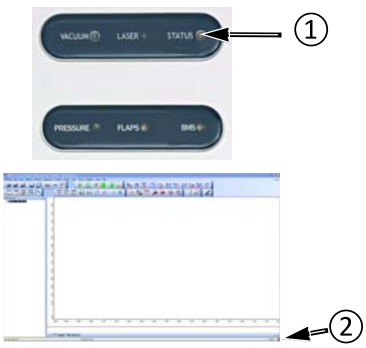
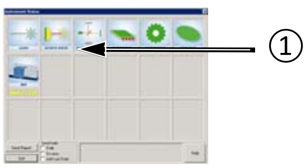
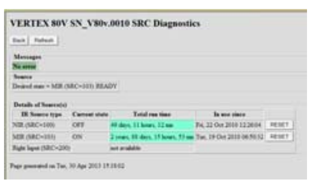
Figure 7.9	Component	Explanation
A	ERR LED (red)	A red ERR LED indicates an interferometer error (e.g. a missing laser signal, a beamsplitter problem). As long as this LED lights, measurement is not possible.
B and C	SR LED (red) and SG LED (green)	These two LEDs indicate the internal operating state of the spectrometer communication processor. (The abbreviation SR stands for 'Status Red' and SG for 'Status Green'.)
D and E	RX LED (green) and TX LED (yellow)	These LEDs indicate the data transfer direction between spectrometer and PC. In case of the stand-alone operation, the green RX LED signals that the spectrometer receives data. In case the spectrometer is connected to an Ethernet network, the green RX LED indicates that a data packet is transmitted on the Ethernet. (This does not necessarily mean that the data packet is destined for the spectrometer!) The yellow TX LED lights when the spectrometer transmits a data packet, i.e. the spectrometer is accessed by a computer. The abbreviation RX stands for 'transmit data' and TX stands for 'receive data'. These LEDs can be used for testing the communication between spectrometer and PC.
F	Voltage status LEDs	The voltage status are labeled +5V, +12V and -12V. They indicate the state of the secondary voltages of the electronics unit.

7.3 General information about how to diagnose a fault

In many cases, 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 OPUS does not display any measurement result. (Reason: OPUS did not start the measurement at all because OPUS has recognized a spectrometer component error.)
- No signal detection or signal intensity is too low. (See section 5.13.)
- 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 OPUS has recognized a spectrometer component error.)
- A failed OQ test or PQ test.

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

1		First check whether the STATUS LED ① on the spectrometer top side or the status lamp ② in OPUS indicate a spectrometer problem. ➢ Are they red?
2		If so, open the OPUS dialog window *Instrument Status* and check whether there is a component having the status WARNING or ERROR.
3		If so, double-click on the component icon in question to look up whether an instrument status message ① is displayed in OPUS. For information about the meaning of the instrument status messages refer to section 7.5.2.
4		For more information about the component in question, open the corresponding diagnostic page of the spectrometer firmware and try to find a hint for the cause of the spectrometer problem. (See section 7.2.4.)

☞ For information about how to eliminate a certain fault, see section 7.5. If the solutions listed in this section do not eliminate a fault contact the Bruker service. (See section 1.6.)

7.4 Remote fault diagnosis

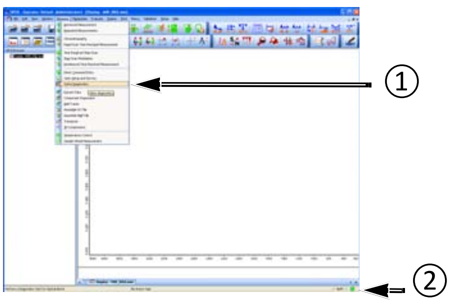
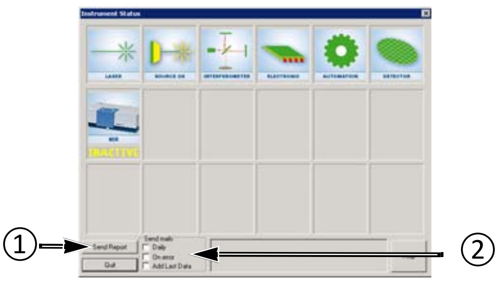
Remote fault diagnosis means that you send a complete spectrometer status report - a so called *Full Report* - by e-mail to Bruker. This report enables a Bruker service technician to perform a first remote fault diagnostics.

Depending on whether your spectrometer is connected to a network or network computer or a stand-alone computer, the procedure for sending the report is different. (For detailed information about the possible connection variants, see section 3.10.2.)

If your spectrometer is connected to a network computer or directly to a network...

☞ With OPUS version 6 or higher, it is possible to send the full report by e-mail to Bruker with just the click of a button. **Important:** The usage of this function requires an e-mail program installed on the network computer and a set-up mail account.

Proceed as follows:

1		Open the OPUS software program, if not already done. Either select in the OPUS *Measure* menu the *Optics Diagnostics* function ① or click on the OPUS status light ②. ➢ Thereupon, the *Instrument Status* dialog opens.
2		Click on the *Send Report* button ①. ➢ As a result of this, the report is sent automatically by e-mail to *opusreports@brukeroptics.de*. ➢ Note: In addition, you can define conditions ② for sending the full report automatically.

If your spectrometer is connected to a stand-alone computer, proceed as follows:

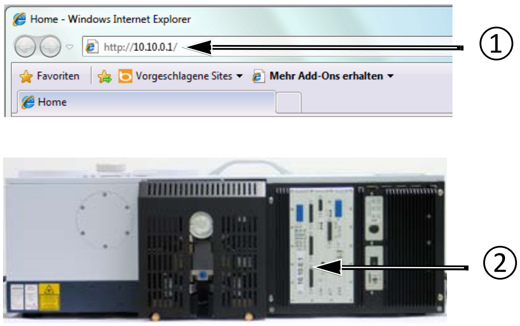
1. Generate a full report manually and save it. (See description below.)
2. Transfer the full report file to a network computer.

☞ Note: The network computer requires an e-mail program and a set-up mail account.

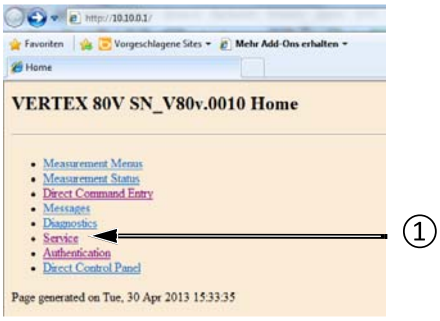
3. Send the full report by e-mail as an attached file to *opusreports@brukeroptics.de*.

Generating and saving a Full Report

☞ It is highly recommended to generate and save the full report instantly after a spectrometer problem or failure has occurred. Otherwise, important information may be overwritten by newer ones.

<table>
<tr>
<td>1</td>
<td>
</td>
<td>Open the web browser and enter the spectrometer IP address into the address field of the web browser ①.

☞ For the spectrometer IP address, see the label ② at the spectrometer rear side.

➢ Note: The spectrometer IP address depends on the realized connection variant. See section 3.10.3.</td>
</tr>
<tr>
<td>2</td>
<td>
</td>
<td>➢ Thereupon, the spectrometer home page opens.

Click on *Service* ①.</td>
</tr>
<tr>
<td>3</td>
<td>
</td>
<td>Click on *Full Report* ①.</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Save the full report as *.htm file for sending it as an e-mail attachment.

Send the full report by e-mail as an attached file to *opusreports@brukeroptics.de.*</td>
</tr>
</table>

7.5 Problem - possible cause - solution

7.5.1 Spectrometer problem indicated by a red status indicator board LED

7.5.1.1 Red VACUUM LED

During a spectrometer evacuation, a red VACUUM LED indicates that the ultimate vacuum inside the spectrometer is not reached (i.e it lights up red if a certain threshold pressure value is not reached within a certain period of time).

Possible causes	Solutions
There is a leakage that allows air to enter the spectrometer. During the evacuation, a leakage may become apparent by a hiss. Possible leakages are: • sample compartment cover has not been placed correctly on the spectrometer, • flaps do not close properly or • the wing-shaped cover is not secured properly (after the beamsplitter has been exchanged) or • a IR beam port cover is not reinstalled properly (after an optional accessory / component has been removed from an IR beam port).	Find the leakage and close it. In case of defective flaps, contact the Bruker service. (See section 1.6)
Vacuum pump is defective.	See the user manual of the vacuum pump.
Vacuum pump is not connected properly.	Check the vacuum pump connection. (For information about how to connect the vacuum pump to the spectrometer, see section 3.8.)
Venting valve(s) do(es) not close. This problem is accompanied by a hissing sound at the spectrometer rear side.	Contact the Bruker service. (See section 1.6)

7.5.1.2 Red LASER LED

Possible causes	Solutions
Spectrometer is still initializing.	In this case, there is not any spectrometer problem. Wait until the spectrometer has completed the initialization successfully. Afterwards, the LASER LED turns automatically to green.
Laser beam inside the interferometer compartment is blocked. In this case the following error message appears: *HeNe-Laser is off or no laser signals*.	Contact the Bruker service. (See section 1.6)
Laser tube is not installed correctly.	Contact the Bruker service. (See section 1.6)
Laser is defective. In this case the following error message appears: *HeNe-Laser is off or no laser signals*.	Contact the Bruker service. (See section 1.6)
Laser signal is too weak because the average laser lifetime is nearly over. In this case the following error message appears: *End of average lifetime is nearly reached, spare part will be required*. (Note: If the laser has been in operation for more than 2 years, a decreased laser performance might be the cause of the problem.)	Look up when the laser was put into operation for the first time. You find this information at the laser diagnostics page. See section 7.2.4. If the average laser lifetime is exceeded (significantly), the laser module needs to be replaced. Contact the Bruker service. (See section 1.6)

7.5.1.3 Red STATUS LED

A red STATUS LED indicates a spectrometer problem which can be caused by a number of spectrometer components (e.g. laser, source, detector). In order to be able to narrow down the problem, it is highly recommended to open the OPUS dialog window *Instrument Status*. See section 7.2.2.

Possible causes	Solutions
Spectrometer is still initializing.	In this case, there is not any spectrometer problem. Wait until the spectrometer has completed the initialization successfully. As soon as the spectrometer initialization is completed successfully, the STATUS LED turns automatically from red to green.
If the **laser** is the cause of the problem either: • the laser beam is blocked (e.g. due to an improperly installed laser) or • the laser power supply cable is not connected and/or secured properly or • the laser is defective. ➢ **Note:** These causes are also indicated by a red LASER LED and by the instrument status message: *HeNe-Laser is off or no laser signals.* ➢ **Note:** The laser has a limited service lifetime of about 25,000 operating hours. Look up the actual service lifetime of the installed laser at the *Laser Diagnostics Page*. See fig. 7.3.)	Contact the Bruker service. (See section 1.6.)
If the **source** is the cause of the problem either: • the selected source is not installed or • the selected source is not installed properly or • the selected source is defective. ➢ **Note**: This problem is indicated by the instrument status message *Source is broken or not connected*.	**Missing source:** Install the source. **Improperly installed source:** Check whether the source is installed properly and correct it, if required. **Defective source:** Order a replacement source. (For the order number refer to appendix B.) After receiving the replacement source, replace the defective source. ☞ For the replacement procedure, see section 6.4.

<table>
<tr><th>Possible causes</th><th>Solutions</th></tr>
<tr><td>If the detector is the cause of the problem:

• either the detector is not installed correctly or
➢ Note: This problem is indicated by the instrument status message Device not connected. No analog board selected.

• the MCT detector is not cooled down to its operating temperature.
➢ Note: This problem is indicated by the instrument status message Detector not ready.</td><td>Improperly installed detector: Check whether the detector is installed correctly and correct it, if required. See section 5.11.

MCT detector temperature is too high: Fill liquid nitrogen into the MCT detector dewar. (See section 5.14.)</td></tr>
<tr><td>If the interferometer (scanner) is the cause of the problem there are a number of possible causes. For example:

• In case of a manually exchangeable beamsplitter, the beamsplitter is not locked.
➢ Note: This problem is indicated by the instrument status message BMS door is open.

• In case of the automatic beamsplitter changer, a beamsplitter holder is not in its normal position. So the automatic beamsplitter changer is not able to move the selected beamsplitter in the operating position.
➢ Note: This problem is indicated by the instrument status message Cassette is open.</td><td>Unlocked beamsplitter: Lock the beamsplitter. See section 5.10.3.

Beamsplitter holder still in loading position: Move the beamsplitter holder back to its normal position. See section 5.10.4.

In case of a different cause, try to narrow down the trouble source by consulting the Scanner Diagnostics Page. (See fig. 7.5.) For error messages regarding the interferometer, see section 7.5.2.3.

If you can not solve the problem, contact the Bruker service. See section 1.6.</td></tr>
<tr><td>If the automation is the cause of the problem there are a number of possible causes.</td><td>Try to narrow down the trouble source by consulting the Automation Units Diagnostics Page. (See fig. 7.8.) For error messages regarding the automation, see section 7.5.2.4.
If you can not solve the problem, contact the Bruker service. See section 1.6.</td></tr>
</table>

Possible causes	Solutions
If the **electronics** is the cause of the problem there are a number of possible causes. For example: • the electronics unit is defective or • there is a short circuit.	First of all, check whether the voltage status LEDs (labeled +5V, +12V and -12V; F in fig. 7.9) at the spectrometer rear side are on. (See section 7.5.5.) **Defective power supply unit:** Contact the Bruker service. (See section 1.6.) **Short circuit:** Interrupt the mains power supply of the spectrometer immediately! If there are external accessories and/or components connected to the CAN bus port or any other spectrometer port, disconnect them. Then reconnect the spectrometer to the mains supply. If this action solves the problem the external circuitry has caused the short circuit. Otherwise, it is an internal problem of the spectrometer electronics. Contact the Bruker service. (See section 1.6.)

7.5.1.4 Red PRESSURE LED

Possible causes	Solutions
The air bearing pressure has fallen below the threshold value of 0.8 bar (11.6 psi) because there is something wrong with the compressed air supply.	Check the compressed-air supply. For information about the compressed-air supply requirements and the connection procedure, see section 3.7.
An internal air hose is defective.	Contact the Bruker service. (See section 1.6.)
Internal pressure loss.	Contact the Bruker service. (See section 1.6.)

7.5.1.5 Red FLAPS LED

Possible causes	Solutions
Upon closing the flaps, they are blocked by an object. (For example, an object has got in the opening while you have worked in the sample compartment.)	Check whether there is something that blocks the flaps. If so, remove it.
Flaps malfunction (i.e. one or both flaps do not open / close properly.)	Contact the Bruker service. (See section 1.6.)

7.5.1.6 Red BMS LED

Possible causes	Solutions
No beamsplitter is installed in the operating position.	Install a beamsplitter in the operating position. (See section 5.10.3.)
In case of a manually exchangeable beamsplitter, the beamsplitter is not locked.	Lock the beamsplitter in position. (See section 5.10.3.)
In case of the automatic beamsplitter changer, a beamsplitter holder is not in its normal position (i.e. it is still in the loading position). So the automatic beamsplitter changer is not able to move the selected beamsplitter in the operating position.	Move the beamsplitter holder back to its normal position. See section 5.10.4.

7.5.2 Spectrometer problem indicated by an instrument status message in OPUS

7.5.2.1 Instrument status message regarding the laser

Instrument status message	Possible causes	Solutions
HeNe laser is off or no laser signal.	Laser tube is not orientated correctly. **OR** Power supply to the laser is interrupted. **OR** Laser is defective.	Contact the Bruker service. (See section 1.6.)
End of average lifetime is nearly reached, spare part will be required.	The end of the specified lifetime of the laser is nearly reached.	The laser needs to be replaced in the near future. Contact the Bruker service. (See section 1.6.) ➢ **Note:** Despite this warning message, measuring is still possible. To turn the OPUS status light green again click on the *Ignore* button in the *Instrument Status Message* dialog (fig. 7.2). The message will be repeated in certain intervals until the laser module has been replaced.

7.5.2.2 Instrument status message regarding the source

Instrument status message	Possible causes	Solutions
Source is broken or not connected.	Source is not installed at all or not installed properly. **OR** Source is defective (e.g. burnt out).	Install the source as described in section 6.4. Order a spare source. (For the order number refer to appendix B.) After receiving the replacement source, replace the defective source. (See section 6.4.)
End of average lifetime is nearly reached, spare part will be required.	The end of the specified lifetime of the source is nearly reached.	The source needs to be replaced in the near future. Order a spare source. (For the order number refer to appendix B.) After receiving the replacement source, replace the defective source. (See section 6.4.) ➢ **Note:** Despite this warning message, measuring is still possible. To turn the OPUS status light green again click on the *Ignore* button in the *Instrument Status Message* dialog (fig. 7.2). The message will be repeated in certain intervals until you have replaced the source.

7.5.2.3 Instrument status message regarding the interferometer

Instrument status message	Possible causes	Solutions
Scanner initialization mode.	This error message appears only if you try to start a measurement while the spectrometer is still initializing. ➢ Also other error messages can be displayed. As in this case there is not a spectrometer problem so you can ignore them.	Before starting a measurement, wait until the spectrometer has completed the initialization successfully. ➢ As soon as the initialization is completed successfully, the red STATUS LED of the spectrometer indicator board turns automatically to green. Now you can start to measure.
BMS door is open.	Beamsplitter is not installed properly (i.e. the beamsplitter is not in the locked position).	Lock the beamsplitter in position. See section 5.10.3.
Cassette is open.	In case of the automatic beamsplitter changer, a beamsplitter holder is not in its normal position (i.e. it is still in the loading position). So the automatic beamsplitter changer is not able to move the selected beamsplitter in the operating position.	Move the beamsplitter holder back to its normal position. See section 5.10.4.
Scanner air bearing pressure is too low.	Spectrometer is not connected to a compressed-air supply line at all. OR Spectrometer is not connected properly to a compressed-air supply line. OR Insufficient pressure.	Connect the spectrometer to a compressed-air supply line. See section 3.7. Correct the connection to the local compressed-air supply line. See section 3.7. Make sure that the pressure of the local compressed-air supply is sufficient. The scanner air bearing requires a pressure between 1 to 2 bars.

Instrument status message	Possible causes	Solutions
Laser-A timing error / Laser-B timing error OR Laser-A modulation too small / Laser-B modulation too small OR Laser signals modulation too small OR Laser period too slow or modulation too small	Interferometer is out of adjustment caused by strong vibrations, for example.	Contact the Bruker service. (See section 1.6.)

7.5.2.4 Instrument status message regarding an automation unit

Instrument status message	Possible causes	Solutions
Pressure in interferometer compartment is unstable. / Pressure in sample compartment is unstable. ➢ These messages are displayed if the defined ultimate pressure is not reached in the compartment in question when evacuating or venting it.	A valve jams. OR Vacuum pump is defective / does not work properly. OR There is a leakage that allows air to enter the interferometer compartment. During the evacuation, a leakage may become apparent by a hissing sound. Possible leakages are: • detector compartment cover / sample compartment cover has not been placed correctly on the spectrometer or • the flaps do not close properly or • the wing-shaped cover is not secured properly (after a beamsplitter exchange) or • an IR beam port cover is not reinstalled properly (after an accessory removal).	Contact the Bruker service. (See section 1.6.) See the user manual of the vacuum pump. Find the leakage and close it. In case of defective flaps contact the Bruker service. (See section 1.6.)

7.5.2.5 Instrument status message regarding the detector

Instrument status message	Possible causes	Solutions
Detector not ready.	The MCT detector is not cooled down to its operating temperature.	Cool down the MCT detector by filling liquid nitrogen into the detector dewar. (See section 5.14.)
Device not connected. No analog board selected. OR No analog board found.	Detector you have selected in OPUS is not installed in the spectrometer.	Install the detector. (See section 5.11.)

7.5.3 No signal is detected or signal intensity is too low

Provided that the spectrometer and the PC are properly connected and switched on and the computer can access the spectrometer, this problem can have the following possible causes:

Possible Causes	Solutions
Beam path is blocked.	Check whether the IR beam is blocked in the sample compartment by an accessory or a sample or another object. Remove the sample / object and check the signal again.
In case of a MCT detector or a thermo-electrically cooled detector, the detector temperature is too high. ➢ This problem is indicated by the instrument status message *Detector not ready*.	**MCT detector:** Fill liquid nitrogen into the MCT detector. (See section 5.14.) **Thermoelectrically cooled detector:** Contact the Bruker service. (See section 1.6)
Detector is not or not properly installed / connected. ➢ This problem is indicated by the instrument status message *Device not connected. No analog board selected*.	**Internal detectors:** Install the detector properly. (See section 5.11.) **External detectors:** Examine the cable connection at the detector as well as at the spectrometer rear side.
Detector oversaturation or A/D converter overflow	Either reduce the source intensity by using a smaller aperture or reduce the gain settings. ➢ Both parameters (aperture and gain) are set in the OPUS dialog *Measurement*. See the OPUS Reference Manual.

Possible Causes	Solutions
Source is not or not properly installed or it is defective. ➢ These problems are indicated by the instrument status message *Source is broken or not connected.*	Install the source properly. (See section 6.4.) If the source is defective, order a replacement source. (For the order number refer to appendix B.) After receiving the replacement source, replace the defective source. (See section 6.4.)
Beamsplitter is not locked in position. ➢ This problem is indicated by the instrument status message *BMS door is open*.	Lock the beamsplitter in position. (See section 5.10.3.)
Beamsplitter is damaged or has become opaque.	Order a replacement beamsplitter. After receiving replacement beamsplitter, replace the beamsplitter. (See section 5.10.3.)
Beamsplitter is not properly installed. ➢ This problem is indicated by the instrument status message *NOT SCANNING. Laser-A modulation too small, Laser-B modulation too small, Laser signal modulation is to small.*	Install the beamsplitter properly. (See section 5.10.3.)
• In case of the automatic beamsplitter changer, a beamsplitter holder is not in its normal position. So the automatic beamsplitter changer is not able to move the selected beamsplitter in the operating position. ➢ **Note**: This problem is indicated by the instrument status message *Cassette is open*.	Move the beamsplitter holder back to its normal position. See section 5.10.4.
A temporary or permanent optics misalignment caused by strong shock.	Place the spectrometer on a vibration-free surface. In case of a temporary optics misalignment, this action can solve the problem. If this action does not solve the problem contact the Bruker service. (See section 1.6.)

Possible Causes	Solutions
If the laser is the cause of the problem either: • the laser beam is blocked (e.g. due to an improperly installed laser) or • the laser power supply cable is not connected and/or secured properly or • the laser is defective. ➢ These causes are also indicated by a red LASER LED and by the instrument status message: *HeNe-Laser is off or no laser signals.* ➢ The laser has a limited service lifetime of about 25,000 operating hours. Look up the actual service lifetime of the installed laser at the laser diagnostics page. (See fig. 7.3.)	In case the laser is the cause of the problem, contact the Bruker service. (See section 1.6.)

7.5.4 A failed validation test

Validation test is a collective term for all tests (e.g. OQ test[1], PQ test[2]) that can be performed with OVP[3] for the purpose of the spectrometer validation[4]. (For detailed information about OVP refer to the OPUS Reference Manual.)

Important note regarding the OQ test

☞ The resolution test, which is part of the OQ test protocol, requires a gas cell filled with CO at low pressure. If you do not have such a gas cell at your disposal, contact the Bruker service. (See section 1.6.)

Possible causes	Solutions
During the validation test measurements, an object (e.g. a sample) in the sample compartment has blocked the IR beam.	Take the sample / object out of the sample compartment and repeat the OVP test.

1. OQ - Operational Qualification (Normally, this test should be performed once a year or at least after the replacement of an optical spectrometer component.)
2. PQ - Performance Qualification (Normally, this test should be perform each day before you start your analytical work and after the replacement of an optical spectrometer component for the purpose of extending the spectral range.
3. OVP - OPUS Validation Program
4. Validating the spectrometer means to check whether the spectrometer system achieves the specified performance parameter values. The spectrometer validation ensures that the measurement results delivered by a validated spectrometer system are correct.

Possible causes	Solutions
Source performance has decreased significantly because the end of its service lifetime is nearly reached. ➢ This problem is indicated by the following message *End of average lifetime is nearly reached, spare part will be required.* ➢ **Note:** To find out of which component - either laser or source - the end of the average lifetime is nearly reached, open in OPUS the *Instrument Status* dialog window. The component in question has the status WARNING.	Order a replacement source. (For the order number refer to appendix B.) After receiving the spare part, replace the source as described in section 6.4.
Sample compartment windows (if installed) are dirty or have become opaque.	Order replacement windows. After receiving them, replace them as described in section 5.12.
Beamsplitter is dirty, opaque or damaged.	Order a replacement beamsplitter. After receiving it, replace the beamsplitter as described in section 5.10.
The spectral ranges of selected optical components (source, beamsplitter and detector) are different. In case the spectrometer is equipped with optional sample compartment windows, the spectral range of the windows does not match with the spectral range of the selected optical components (source, beamsplitter and detector).	Select source, beamsplitter, detector and windows (if installed) of a matching spectral range and repeat the OVP test. See also section 5.9. For information about the spectral range of the available sources, detectors, beamsplitters and sample compartment windows refer section 4.2.2, 4.2.3, 4.2.4 and 4.2.7.)
After you have filled liquid nitrogen in the MCT detector, you start the OVP test without waiting until the detector has reached its operating temperature.	Wait until the detector has reached its operating temperature. Then, repeat the OVP test.
Ice formation on the MCT detector dewar. ➢ This problem becomes apparent by a failed ice band test. This test is part of the PQ test procedure.	Evacuate the MCT detector dewar. (See section 6.3.) Afterwards, repeat the OVP test.
Air humidity content inside the spectrometer is too high. ➢ **Note:** This problem becomes apparent by a failed water vapor test. This test is part of the OQ test procedure.	Reduce the air humidity content inside the spectrometer by either evacuating the spectrometer or purging it with dry air or nitrogen gas. Afterwards, repeat the OVP test. For evacuating the spectrometer, see section 5.6. For purging the spectrometer, see section 5.8.

Possible causes	Solutions
Interferogram peak position has shifted.	Save the new peak position using the OPUS software. See section 5.13.3 Afterwards, repeat the OVP test.
If a failed OVP test has a different cause (e.g. detector sensitivity has weakened or interferometer is out of adjustment due to shock etc.) ...	... contact the Bruker service. (See section 1.6)

7.5.5 Spectrometer problem indicated by the voltage status LEDs

The voltage status LEDs (F in fig. 7.9) are at the spectrometer rear side, labeled +5V, +12V and -12V. These LEDs indicate the state of the secondary voltages of the electronics unit.

7.5.5.1 All voltage status LEDs are off

Possible causes	Solutions
Spectrometer is off.	Switch on the spectrometer. (See section 5.2.)
Spectrometer is not connected to the power supply.	Connect the spectrometer to the power supply. (See section 3.6.)
No voltage is applied.	Check whether the local power supply fulfills the requirement. (See section 3.5.)
Short circuit in the power supply unit of the spectrometer.	Typically, a short circuit is accompanied by a “ticking” sound in the power supply unit. Interrupt the mains power supply immediately! If there are external accessory and/or components connected to the CAN bus port or any other spectrometer port, disconnect them. Then reconnect the spectrometer to the mains supply. If this action solves the problem the external circuitry has caused the short circuit. Otherwise, it is an internal problem of the spectrometer electronics. Contact the Bruker service. (See section 1.6.)
Defective power supply unit.	If the voltage status LEDs do not light correctly, probably the power supply unit needs to be replaced. If they do not light at all, contact the Bruker service. (See section 1.6.)

7.5.5.2 One voltage LED is off

Possible causes	Solutions
An external accessory / component causes a short circuit in the power supply unit of the spectrometer.	Switch off the spectrometer and disconnect all externally connected accessories and/or components from the CAN bus port or any other port at the spectrometer rear side. Then switch on the spectrometer. (See section 5.2 and 5.3.)
Temporary short circuit in the spectrometer.	Switch off the spectrometer, wait about 30 seconds and switch it on again. (See section 5.2 and 5.3.)
A defective LED.	In this case there is no spectrometer malfunction and the spectrometer operates properly. Only the defective LED should be replaced. In case of doubt, contact the BRuker service. (See section 1.6.)

7.5.6 Spectrometer problem indicated by a red ERR LED

A red ERR LED indicates a scanner malfunction, i.e. all components and/or conditions that are involved in the scanner functioning (laser, beamsplitter, air bearing pressure etc.) can cause a red ERR LED.

Possible causes	Solutions
If the **laser** is the cause of the problem either: • the laser beam is blocked or • the laser tube is not installed correctly or • the laser is defective. ➣ These causes are also indicated by a red LASER LED.	Contact the Bruker service. (See section 1.6.)
In case the **beamsplitter** is the cause of the problem either: • no beamsplitter is installed in the operating position or • the beamsplitter is not locked in position or • it is damaged or has become opaque. ➣ The first two causes are also indicated by a red BMS LED.	**Missing beamsplitter:** Install a beamsplitter. (See section 5.10.) **Unlocked beamsplitter:** Lock the beamsplitter in position. (See section 5.10.3.) **Damaged or opaque beamsplitter:** Order a replacement beamsplitter. After receiving, install the beamsplitter. (See section 5.10.)

Possible causes	Solutions
Air bearing pressure is fallen below the threshold value of 0.8 bar (11.6 psi) because either there is something wrong with the local compressed air supply or an internal hose is defective. ➢ These causes are also indicated by a red PRESSURE LED.	**Insufficient air bearing pressure:** Check the pressure of the local compressed-air supply. Make sure that the pressure of the compressed air is at least 1.0 bar (14.5 psi). (See also section 3.7.) **Defective internal air hose:** Contact the Bruker service. (See section 1.6.)
Strong mechanical shocks have caused a permanent optics misalignment.	Contact the Bruker service. (See section 1.6.)

7.5.7 The SR LED lights permanently

As long as the SR LED[1] (B in fig. 7.9) lights, the spectrometer is busy and not available for communicating with the PC.

Possible causes	Solutions
Spectrometer is still in the initialization phase.	In this case, there is not any spectrometer problem. Wait until the spectrometer initialization is completed. ➢ As soon as the spectrometer initialization is completed successfully, the STATUS LED at the status indication board of the spectrometer turns automatically from red to green.
Spectrometer control hangs.	Reset the spectrometer using the reset button (R in fig. E.1) at the spectrometer rear side and wait for initialization to terminate. If this action does not solve the problem, contact the Bruker service. (See section 1.6.)

7.5.8 No communication between spectrometer and computer

In case of communication problems between the spectrometer and the PC, the troubleshooting procedure depends on the actually realized connection variant. For detailed information about this topic, see section 3.10.

The direction of the data transfer is indicated by the LEDs RX and TX at the spectrometer rear side. The TX LED (E in fig. 7.9) lights during the spectrometer sends data and the RX LED (D in fig. 7.9) lights during the spectrometer receives data. (See also section 7.2.5.

1. The SR LED together with the SG LED indicate the internal operating state of the spectrometer communication processor. (The abbreviation SR stands for *Status Red*.)

7.5.8.1 The green RX LED does not light at all

This indicates a problem with regard to the physical connection between the spectrometer and the PC or the network.

Possible causes	Solutions
With regard to the existing connection variant, the wrong data cable type is used.	The data cable type (cross-over or straight), which has to be used, depends on the realized connection variant. (For information about which data cable type has to be used for which connection variant, see section 3.10.1.) Procure a data cable of the correct type. and replace the data cable.
Data cable connector is loose.	Check both data cable connectors for tight fit, i.e. at the Ethernet port at the spectrometer rear side and at the PC. Connect the data cable properly. (See section 3.10.1.)
Data cable is damaged.	Check the data cable for damages. If it shows signs of damages, replace it.
Spectrometer does not start up.	Check whether the spectrometer is connected to a mains socket outlet. (See section 3.6.) Check whether the mains supply meets the requirements. (See section 3.5.) Check whether the spectrometer is switched on. (See section 5.2.) If these actions do not solve the problem contact the Bruker service. (See section 1.6.)

7.5.8.2 During connection establishment the RX LED lights but the TX LED does not

This indicates that there is no logical connection between the spectrometer and network or computer.

Possible causes	Solutions
With regard to the realized connection variant, the wrong IP address has been assigned to the spectrometer. **Note:** The correct spectrometer IP address depends on the existing connection variant. (See section 3.10.3.)	Assign the correct IP address to the spectrometer. (See section 3.10.4.)
TCP/IP settings mismatch between spectrometer and computer/network.	Refer to the documentation of the operating system Windows.

Hint: 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. Click in the Window desktop on the *Start* button.
2. Select *Run*.
3. Enter *cmd* and click OK.
4. Enter *route print* and press the ENTER key.
5. Then, enter i*pconfig/all* and press the ENTER key again.
6. Take a screenshot of the dialog (fig. 7.10) and provide it for your network administrator.

Figure 7.10: Useful information for solving the communication problem between PC and spectrometer

A Specification

A.1 Spectrometer

Parameter	Specification
Weight	Basic spectrometer configuration: approx. 120 kg (Note: The concrete weight depends on the individual instrument configuration.)
Dimensions	85cm (W) x 70cm (D) x 30cm (H)
Spectral range	**standard:** With the standard optical components (KBr beamsplitter, DLaTGS detector and MIR source) the following spectral range is achieved: MIR: 8,000 to 350cm^{-1} **optional:** With the corresponding optional optical components, the following spectral ranges can be achieved: Far IR/THz: 680 to 5cm^{-1} Near IR: 15,500 to 4,000cm^{-1} Visible: 25,000 to 9,000cm^{-1} Ultraviolet: 50,000 to 25,000cm^{-1}
Spectral resolution	**standard:** better than 0.2cm^{-1} **optional:** better than 0.06cm^{-1}
Wavenumber accuracy	better than 0.01cm^{-1} @ 2,000cm^{-1}
Photometric accuracy	better than 0.1% T
Scan speed	**standard:** 12 velocities from 1.6 to 160kHz (1.0 to 100mm/sec opd[a]) **optional:** 5 additional velocities (200 kHz, 240 kHz, 280 kHz, 300 kHz and 320 kHz)
Detector	**standard:** High sensitivity DLATGS detector with KBr window **optional:** various detectors for measurements in the NIR, MIR, FIR, UV and VIS region (See also section 4.2.3.)
Laser	VERTEX 80v is a laser class 2 product containing a laser class 3R laser according to EN 60825-1:2007. Divergence angle: 0.2 mrad
Interferometer	Actively aligned UltraScan interferometer with linear air bearing scanner

Parameter	Specification
Sample compartment	Dimension: 25.5cm (W) x 27.0cm (D) x 16.0cm (H) The sample compartment is evacuable and purgeable. Optionally, sample compartment can be separated from the optical bench by windows mounted on either the flaps or the sample compartment walls. Alternatively, the sample compartment can be separated from the optical bench by flaps without windows.
Electronics	Microprocessor-controlled optics bench with digital speed control, system diagnostics, advanced system check, 96 kHz A/D converter with 24 bit dynamic range. Industry standard Ethernet connection
Housing	Vacuum-tight cast aluminum housing
Vacuum	Evacuable below 5mbar

a. opd - optical phase difference

A.2 Power supply

Parameter	Specification
Voltage	Spectrometer: 100 - 240 VAC ± 10%; 50 - 60 Hz
Power consumption (basic spectrometer configuration)	80W typical, 180W max.
Overvoltage category	II according to EN 61010-1 or IEC 60664-1
Pollution degree	2 according to EN 61010-1 or IEC 60664-1
Protection class	I according to IEC 61140

➢ For the power supply specifications of the vacuum pump and the data system, see the corresponding user manual.

A.3 Compressed air supply

Parameter	Specification
Compressed air properties	air or nitrogen gas dry and clean (oil-free and dust-free) dew point below -15°C,

Parameter	Specification
Pressure range	min. 1.0 bar (14.5 psi) max. 2.0 bar (29 psi)
Flow rate	< 100 l/h

➢ Compressed air is required for a proper functioning of the scanner air bearing.

A.4 Purge gas supply

Parameter	Specification
Purge gas properties	air or nitrogen gas dry and clean (oil-free and dust-free) dew point below -40°C (corresponds to to a degree of dryness of 128ppm humidity)
Pressure range	min. 1.0 bar (14.5 psi) max. 2.0 bar (29 psi)
Flow rate	Short-term: Flow rate should not exceed 500 l/h. Long-term: Recommended flow rate is 200 l/h.

➢ Note: As an alternative to the vacuum operation, the spectrometer can be purged.

A.5 Environmental conditions

Parameter	Specification
Ambient temperature range	18 - 35°C (64 - 95°F)
Ambient temperature variations	max. 1°C per hour and max. 2°C per day
Humidity (non-condensing)	≤ 80% (relative humidity)
Installation site	in a closed room, max. 2000m above sea level

B Replacement parts

B.1 Source

Order number	Replacement part
Q 328/7	MIR source, mounted, 12 V
Q 428/7	NIR source, mounted, 12 V

B.2 Beamsplitter

Order number	Replacement part
T303/8	KBr beamsplitter, standard, (MIR), 8,000 to 350 cm^{-1}
T304/8	KBr beamsplitter, broad band, (MIR), 10,000 to 400 cm^{-1}
T401/8	CaF_2 beamsplitter (NIR), 15,000 to 1.200 cm^{-1}
T602/8	CaF_2 beamsplitter (NIR/VIS/UV), 50,000 to 4.000 cm^{-1}
T222/8	Multilayer beamsplitter (FIR), 680 to 30 cm^{-1}
T204/8	Mylar beamsplitter, 25 µm (FIR), 120 to 20 cm^{-1}
T205/8	Mylar beamsplitter, 50 µm (FIR), 60 to 10 cm^{-1}
T208/8	Mylar beamsplitter, 125 µm (FIR), 22 to 5 cm^{-1}

B.3 Windows

Windows flanged to the sample compartment walls and windows mounted on the flaps.

➢ Note: For both optional variants, the windows are identical (diameter: 49.5mm).

Order number	Replacement part
F131-1	Quartz window
F131-3	CaF_2 window
F131-4	NaCl window
F131-5	KBr window
F131-6	KRS-5 window
F131-7	CsI window
F131-8	Si window
F131-9	Polyethylene window
F131-11	ZnSe window
F131-17	BaF_2 window

Windows for telescopic-type insert

➢ For this optional variant, the windows have a diameter of 35mm.

Order number	Replacement part
F173-3	CaF_2 window
F173-5	KBr window
F173-9	Polyethylene window

C Measurement parameters

C.1 General information

Before starting a measurement, you have to define the measurement parameters using the OPUS software. To do this, select in the OPUS *Measure* menu the *Advanced Measurement* function and enter adequate measurement parameter values. The selected parameter settings and values are stored in a XPM-file.

For detailed information about this topic, refer to the OPUS Reference Manual.

C.2 Default parameter values and settings

For VERTEX 80v, the following xpm-files are delivered with OPUS:

- MIR_TR.XPM (for MIR measurements in transmittance)
- MIR_ATR.XPM (for MIR measurements with an ATR accessory)
- MIR_ATR_preview.XPM (for MIR measurements with an ATR accessory and with the preview mode being activated))
- MIR_DRIFT.XPM (for MIR measurements in diffuse reflectance)
- MIR_Refl_30.XPM (for MIR measurements in reflectance; the accessory is designed for a reflection angle of 30°.)

These XPM-files include the standard parameter settings and values for dedicated types of measurement (e.g. transmittance, reflectance, ATR).

Take into consideration that depending on the actual spectrometer configuration, different measurement parameter settings and values may apply. Especially the optics parameter settings depend on the spectrometer configuration. In this case, you have to adapt the parameter settings and values correspondingly.

The following table lists the standard parameter values and settings which apply to the standard spectrometer configuration for a MIR measurement in transmittance.

Advanced parameters	Settings and values
Resolution	4
Sample/Background Scan Time	6 scans
Save Data	from 7500 to 400cm^{-1}
Result Spectrum	Transmittance
Data Blocks to be saved	Transmittance and Single Channel
Optics Parameter	**Settings**
Source Setting	MIR source (#1)
Beam splitter	KBr

Optical Filter Setting[a]	open
Aperture Setting[b]	6mm
Sample/Background Measurement Channel	Sample Compartment
Detector Setting	RT-DLaTGS (#1)
Scanner Velocity	10 kHz
Sample Signal Gain	automatic
Background Signal Gain	automatic
Delay after Device Change	3
Delay before Measurement	0
Acquisition Parameters	**Setting**
Wanted High Frequency Limit	15.500cm^{-1}
Wanted Low Frequency Limit	0cm^{-1}
High Pass Filter	open
Low Pass Filter	10kHz
Acquisition Mode	Double Sided - Forward/Backward
Correlation Mode	OFF
FT-Parameters	**Settings**
Phase Correction	32cm^{-1}
Phase Correction Mode	Power Spectrum
Apodization Function	Blackman-Harris3-Term
Zerofilling Factor	2

a. Note: The available optical filter options (NG4, NG9, NG11 and polystyrene) are used for OQ and PQ tests only. When such a test is running, the correct filter is moved automatically in the beam-path, i.e. it does not need to be selected explicitly by the user. Normally, these optical filters are not intended for spectroscopic measurements. For this reason, select by default the optical filter setting Open when defining the measurement parameters. Note: There are vacant filter wheel positions which can be equipped with optional filters (filter diameter: 25mm), if desired. They can be used for customer-specific applications.

b. By default, the aperture wheel has 12 occupied positions which allow for the following aperture settings: 0.25, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 5, 6, and 8mm. The optimal aperture setting depends mainly on the detector and the source which are currently used and on whether the measurement is to be performed using a special accessory or not. As a rough guideline: The more sensitive a detector is the smaller the aperture should be (e.g. MCT: ca. 2mm). In case of an accessory having a small measurement spot, select a small aperture (e.g. A518, reflection unit, grazing incidence 80°: < 1mm). Note: In addition to the 12 default aperture wheel positions, there are four vacant aperture wheel positions which can be equipped with customer-specific apertures, if desired. These optional aperture settings are selectable by direct commands.

C.3 Interactive setting of optics parameters

The OPUS software provides the option to set the optics parameters *Source Setting*, *Detector Setting* and *Measurement Channel* also interactively using the schematic presentation of the beam path. To do this, click in the *Measurement* dialog on the *Beam Path* tab. The following window opens:

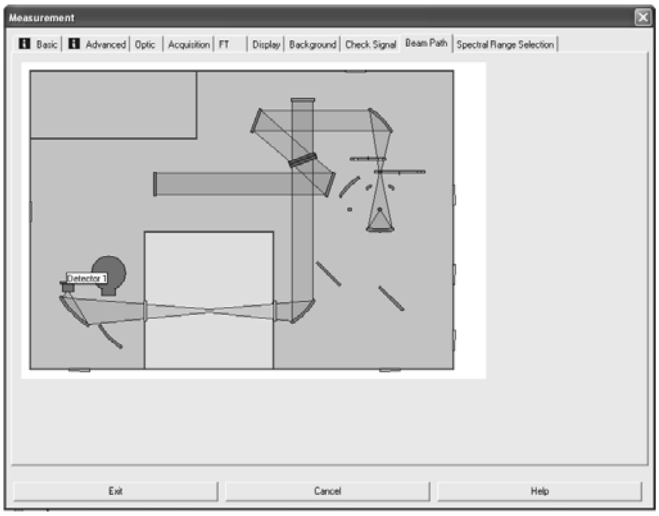


Figure C.1: OPUS dialog page - Beam Path

To select the detector position 2, for example, place the cursor on this detector so that the label *Detector 2* occurs and double-click on this position. The setting will switch to detector 2. See fig. C.2. As soon as you click on the *Check Signal* tab, the spectrometer implements the settings.

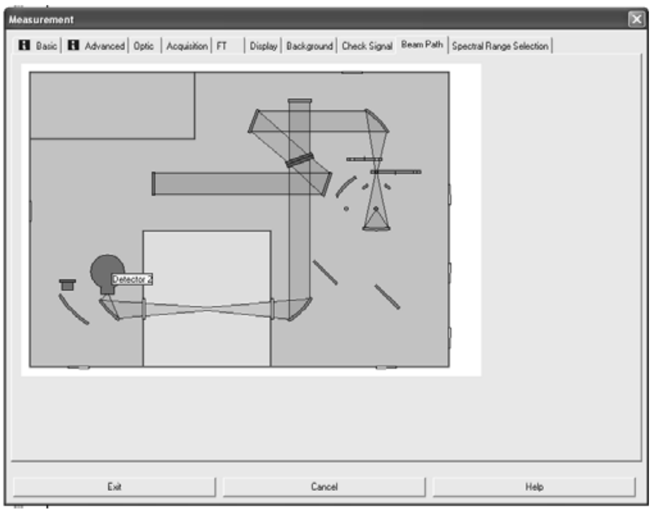


Figure C.2: Changing the detector position interactively

☞ In this way, you can also change the *Source Setting* and *Measurement Channel*.

➢ The parameters you have set in the schematic presentation of the beam path are realized automatically by the software also in the corresponding fields on the *Optics* page and vice versa.

D Dimensional drawings

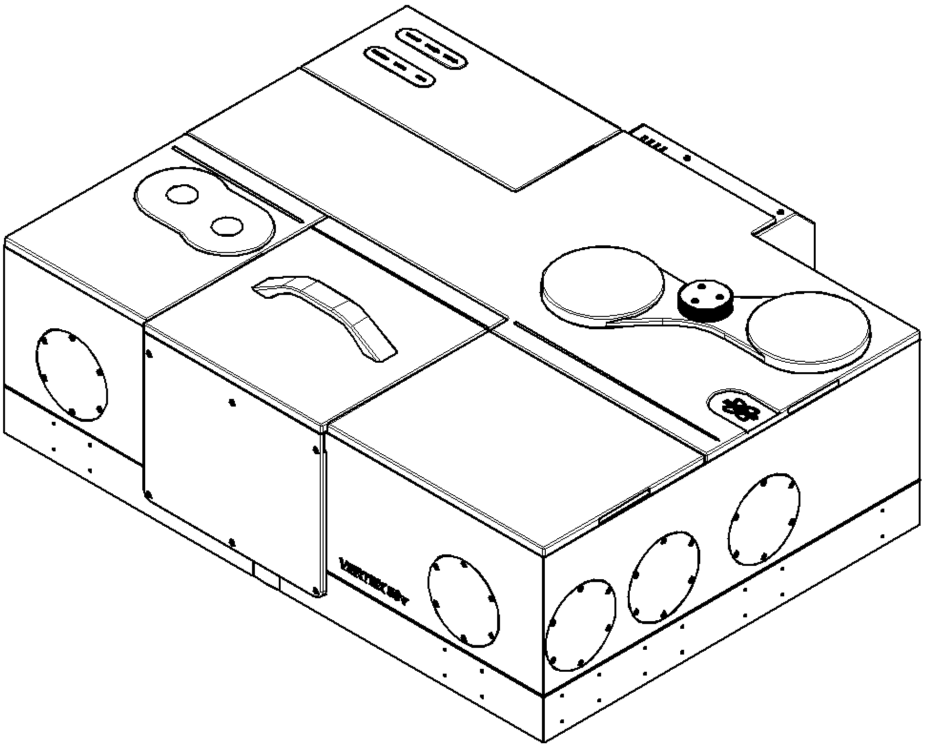


Figure D.1: VERTEX 80v - Isometric view

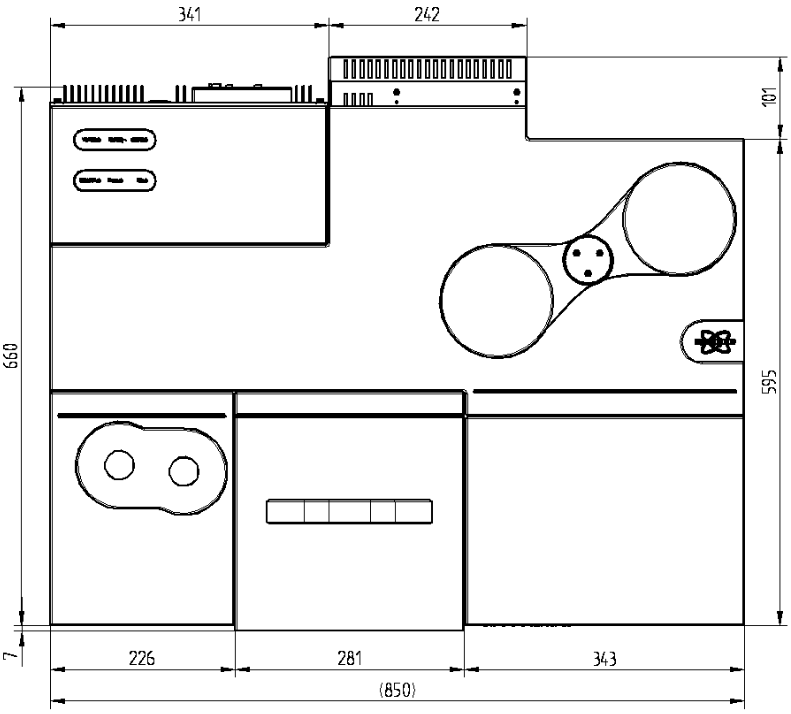


Figure D.2: VERTEX 80v - Top view

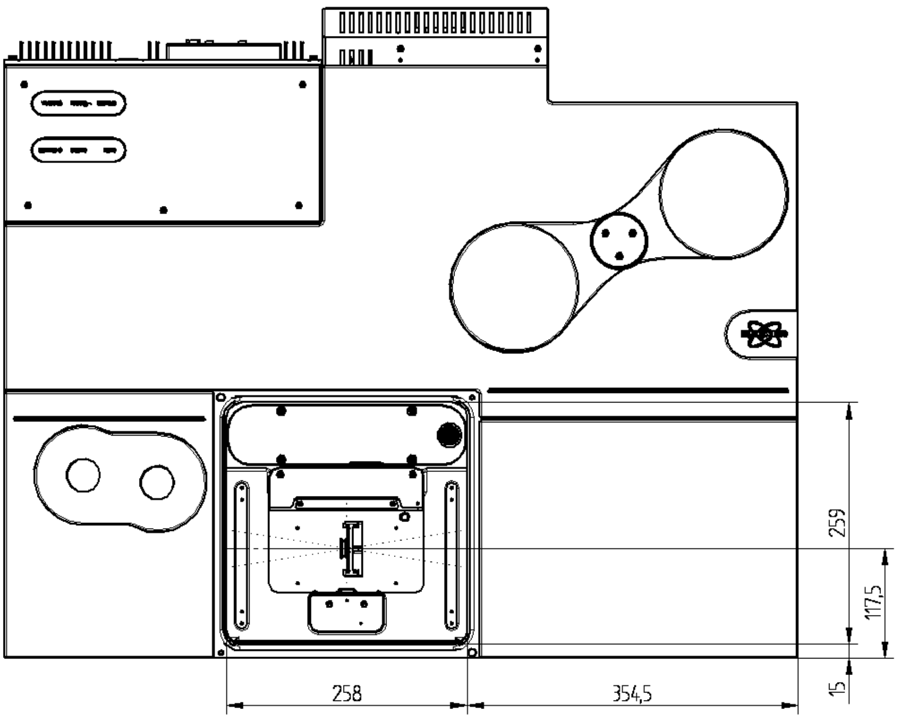


Figure D.3: VERTEX 80v - Top view showing sample compartment dimensions

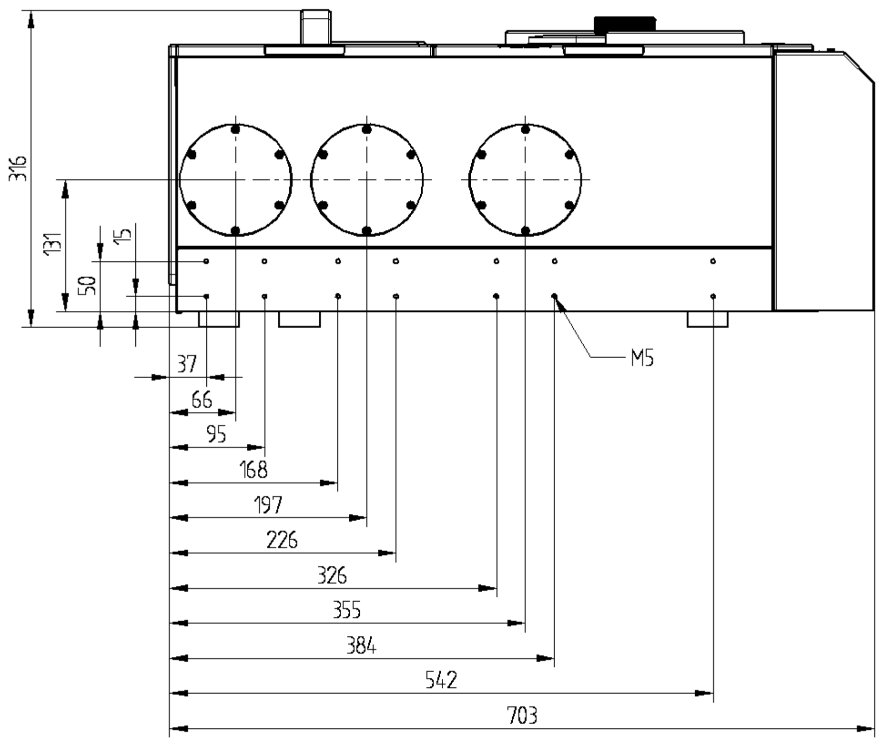


Figure D.4: VERTEX 80v - Right side view

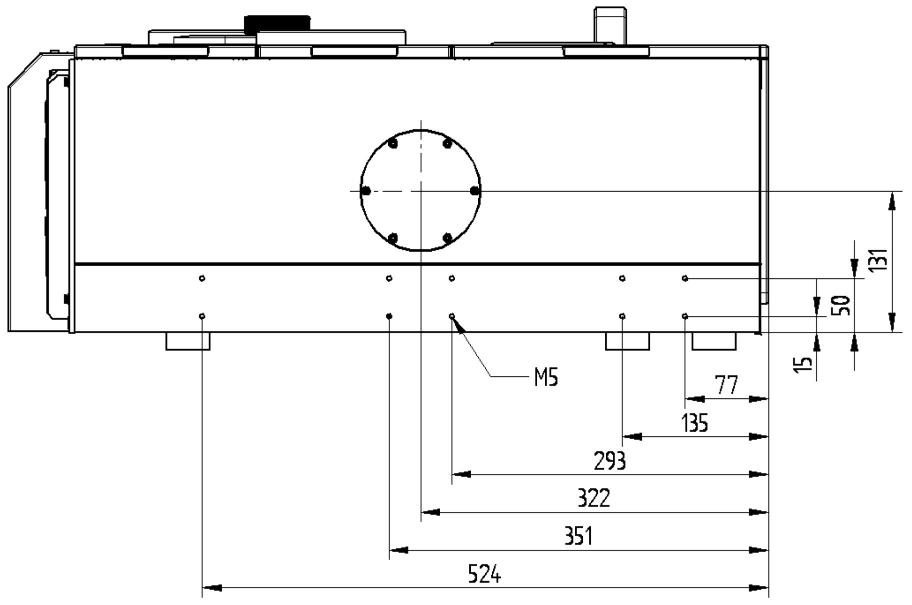


Figure D.5: VERTEX 80v - Left side view

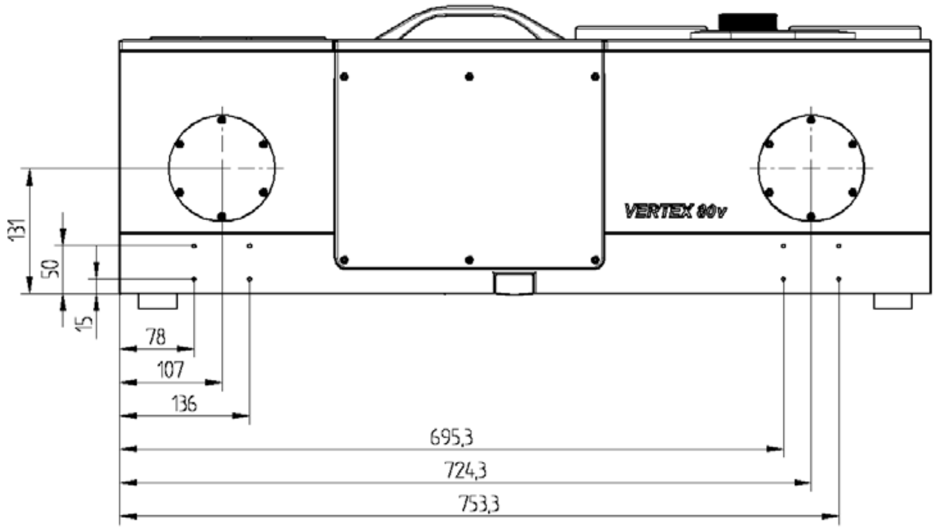


Figure D.6: VERTEX 80v - Front view

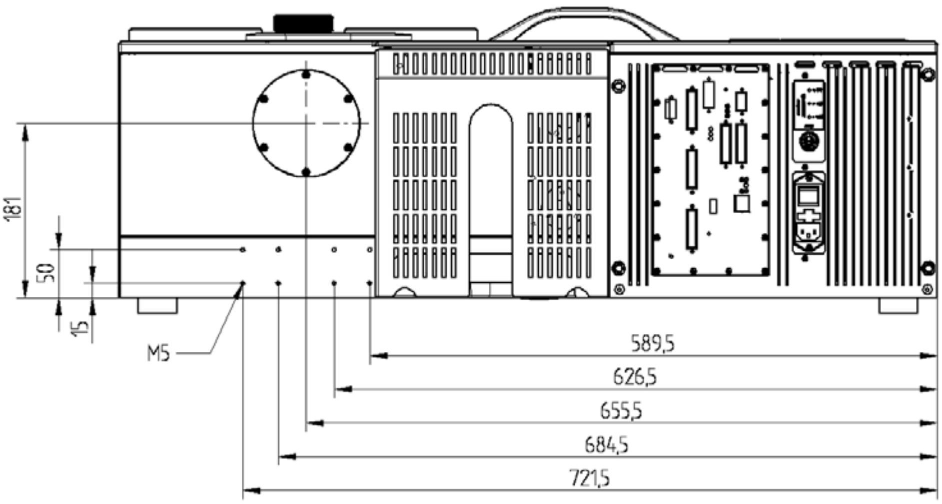


Figure D.7: VERTEX 80v - Rear view

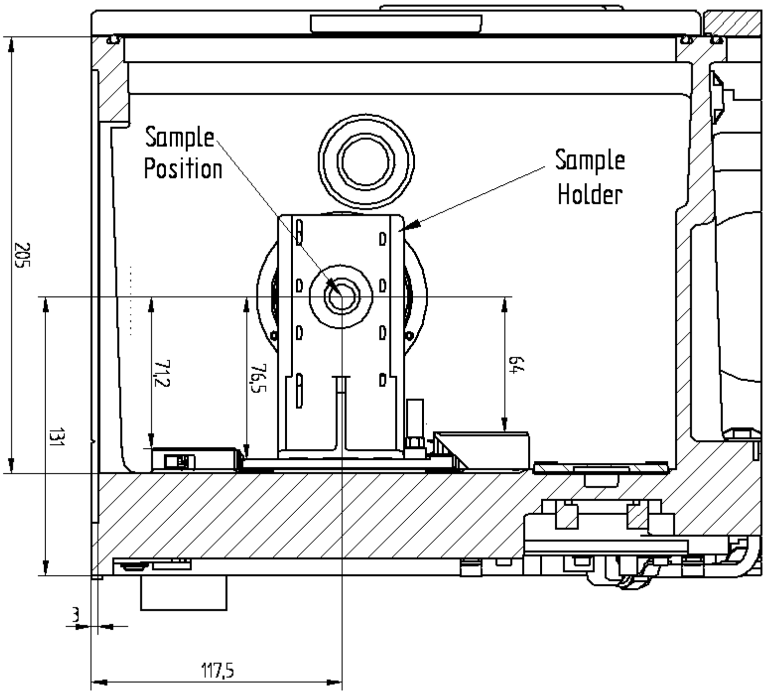


Figure D.8: VERTEX 80v - Sample compartment interior (right side view)

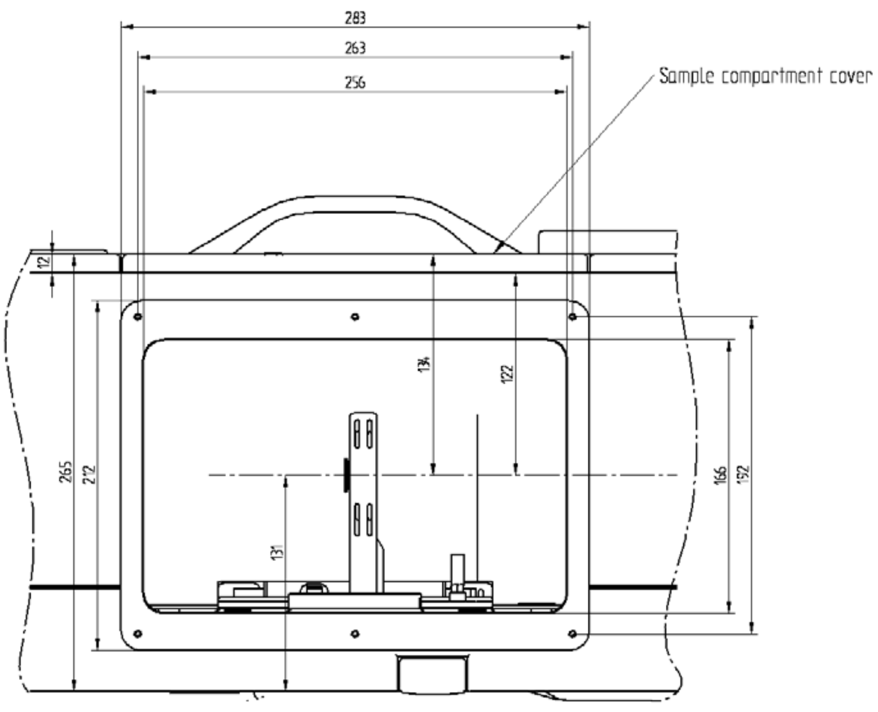


Figure D.9: VERTEX 80v - Sample compartment interior (front view)

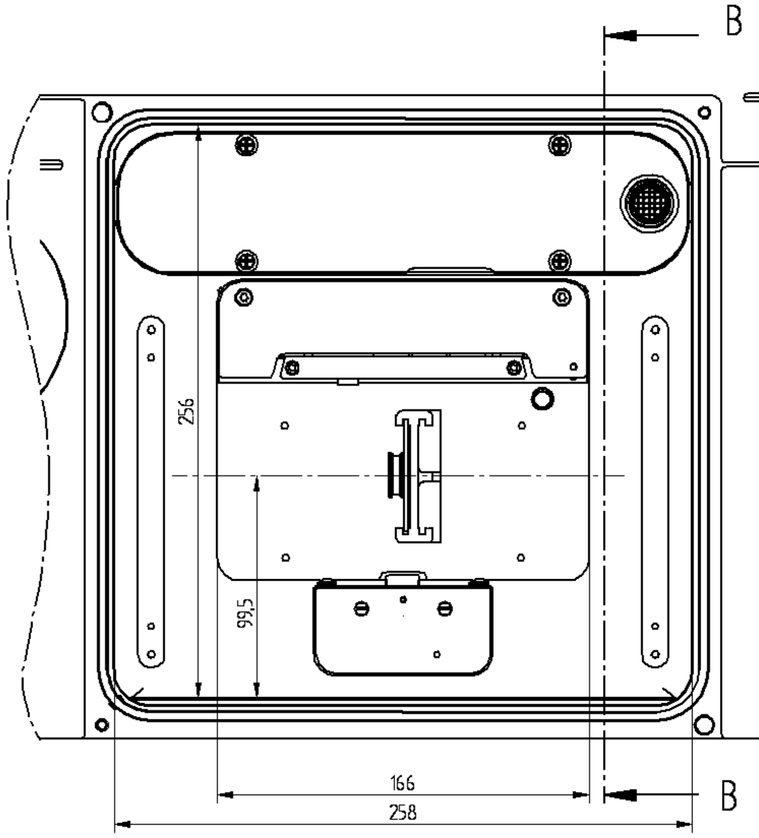


Figure D.10: VERTEX 80v - Sample compartment interior (top view)

E Electronics & power supply unit

E.1 Electronics unit - Diagnostic LEDS and connecting ports

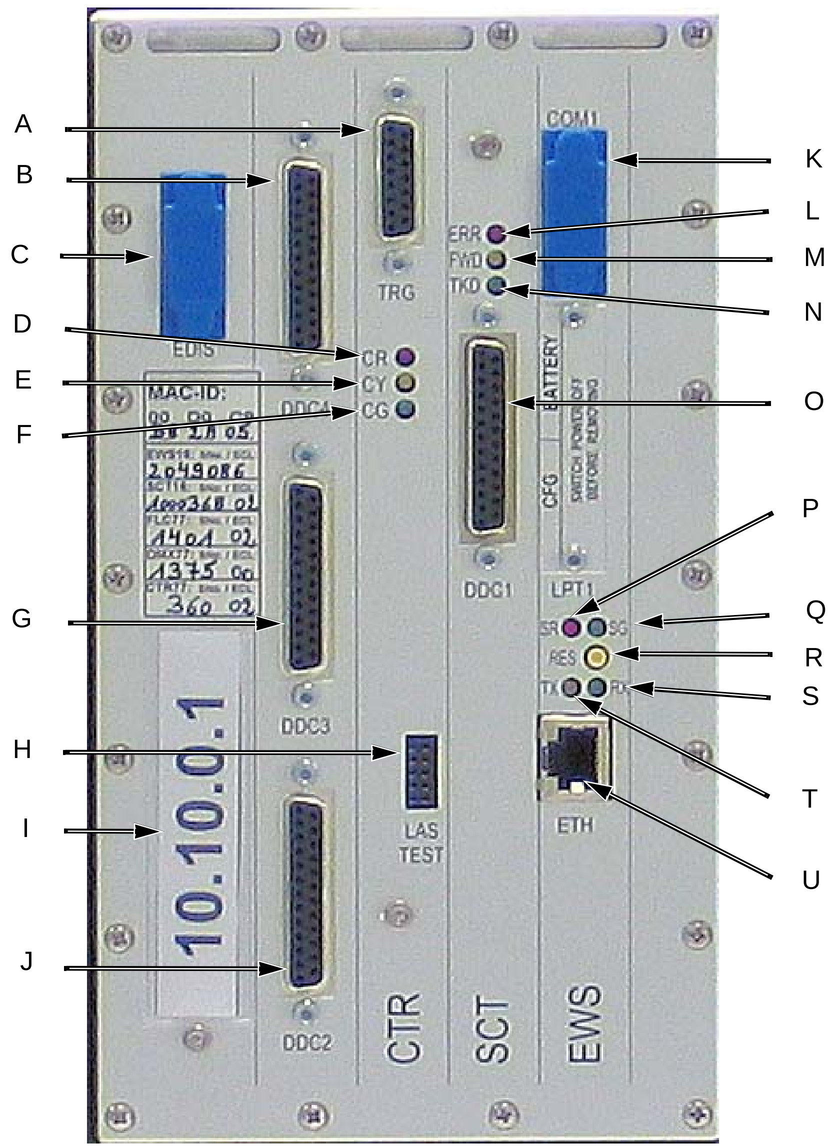


Figure E.1: Electronics unit (detail view)

Fig. E.1	Component	Explanation
A	TRG port	The 15-pin TRG port is intended for the connection of a triggering device. This port is only used in conjunction with the Step Scan option for step scan and time-resolved measurements. (The abbreviation TRG stands for "Trigger".) (For detailed information refer to the Step Scan Manual.)
B	DDC4	The ports DDC 1 to 4 (B, G, J and O in fig. E.1) are versatile ports to connect external optical modules and detectors. These ports include a complete CAN bus, transmits all required remote trigger signals and establishes a complete connection to DDC (Digital Detector Connection) compatible detectors. (Note that the DDC 4 port can not be used if a detector is connected to the DDC 4 port inside the spectrometer. In this case, a cap is fixed to the DDC 4 port.)
C	EDIS port	The EDIS port has no function at the moment. (The abbreviation EDIS stands for "External Display".)
D, E and F	CR, CY and CG LEDs	These LEDs are status and diagnose LEDs for the step scan option. They indicate the status of the controlling device. (The abbreviation CR stands for "Controller Red", CY for "Controller Yellow" and CG for "Controller Green".) (For detailed information refer to the Step Scan Manual.)
G	DDC 3	See explanation for component B.
H	LAS TEST port	The port LAS TEST is intended for service and diagnostic purposes only. Do not connect a device to this port!
I	Spectrometer IP address	For detailed information about the spectrometer IP address, see section 3.10.3.
J	DDC 2	See explanation for component B.
K	COM1 port	This port is technically similar to a conventional, PC-compatible serial port, however, it does not have the complete functionality like serial port of a PC. It is only used for special applications.
L	ERR LED (red)	A red ERR LED indicates an interferometer error (e.g. missing laser signal). As long as this LED lights, data acquisition is not possible. (For troubleshooting, see section 7.5.6.)
M	FWD LED (yellow)	This LED indicates the current interferometer mirror movement. As long as the interferometer mirror moves forward this LED lights. During the backward movement the LED does not light. Thus, the LED flashes in the rhythm of the interferometer mirror forward and backward movement. This rhythm depends on the chosen measurement parameters (e.g. resolution and velocity). (The abbreviation FWD stands for "forward".)

Fig. E.1	Component	Explanation
N	TKD LED (green)	This LED indicates that the interferometer mirror is within the data acquisition range. Typically, it flashes with twice the frequency and synchronous to the FWD LED. During data acquisition the light intensity changes to bright green. (The abbreviation TKD stands for "take data".)
O	DDC1	See explanation for component B.
P and Q	SR LED (red) and SG LED (green)	These two LEDs indicate the internal operating state of the spectrometer communication processor. (The abbreviation SR stands for "Status Red" and SG for "Status Green".) (For troubleshooting, see section 7.5.7.)
R	RES (reset button)	Pressing this button longer than 1 second resets the spectrometer without the need to turn it off. The effect is identical to switching the spectrometer off and on again. In addition, this button can be used to assign an IP address to the spectrometer. See section 3.10.4.
S and T	RX LED (green) and TX LED (yellow)	These LEDs indicate the data transfer direction between spectrometer and PC. In case of the stand-alone configuration, the green RX LED signals that the spectrometer receives data. In case the spectrometer is connected to an Ethernet network, the green RX LED indicates that a data packet is transmitted on the Ethernet (This does not necessarily mean that the data packet is destined for the spectrometer!) The yellow TX LED lights when the spectrometer transmits a data packet, i.e. the spectrometer is accessed by a computer. Note: The abbreviation RX stands for "transmit data" and TX stands for "receive data". You can use these LEDs to test the operational reliability of the Ethernet connection. In case of communication problems see section 7.5.8.
U	ETH (Ethernet port)	This port is used to connect the spectrometer to a PC or to a network (Ethernet standard 10/100Base-T). For detailed information, see section 3.10. The ETH port is designed for RJ-45 plugs and complies with the 10/100Base-T standard.

E.2 Power supply unit - Diagnostic LEDs and connecting ports

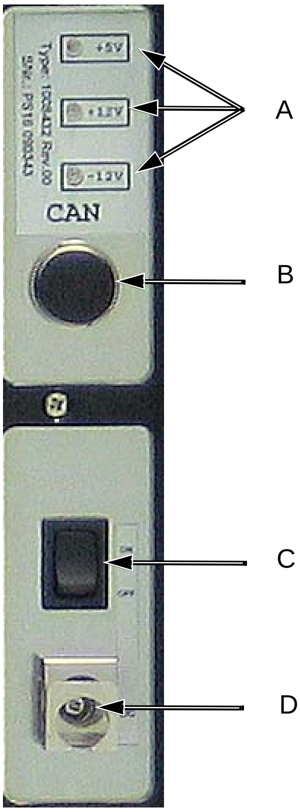


Figure E.2: Power supply unit (detail views)

Fig. E.2	Component	Explanation
A	Voltage status LEDs (+5V, +12V, -12V)	The voltage status are labeled +5V, +12V and -12V. They indicate the state of the secondary voltages of the electronics unit. Note: A dark voltage status LED indicates a major electronics problem. For troubleshooting, see section 7.5.5.
B	CAN bus port	The CAN bus connector is primarily used to connect external automated units (e.g. sample changer, moving mirror unit, etc.) 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. Furthermore, the CAN bus can be used as a communication link to control these external units via the spectrometer. (The abbreviation CAN stands for Controller Area Network.)
C	ON/OFF switch	The on/off switch is used to switch the spectrometer on and off. (See section 5.2 and section 5.3.)
D	Low-voltage socket (male connector)	The low-voltage socket is used to connect the low-voltage cable of the external power supply unit to spectrometer. For connecting the spectrometer to the power supply, see section 3.6.

F Spectrometer firmware

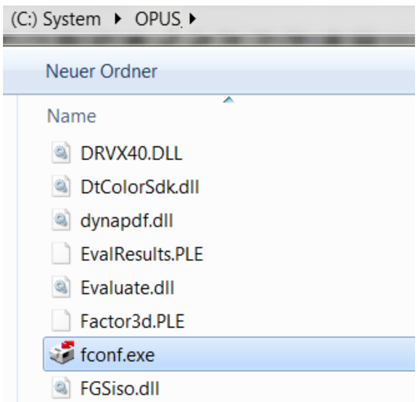
F.1 General information

All spectrometer-firmware-related tasks are executed by the FCONF program (Firmware Configuration Tool), namely:

- 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!).
- assigning a new IP address to the spectrometer (See section 3.10.4.)

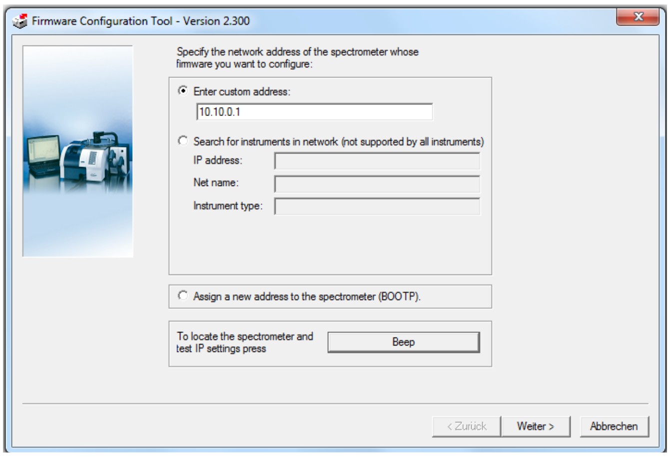
F.2 Starting the FCONF program

1. Browse in the file manager to the OPUS program directory and start the FCONF program by double-clicking on *fconf.exe.*



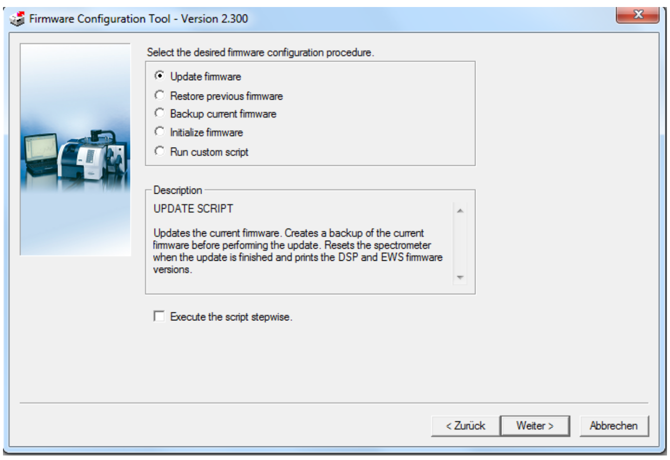
☞ Note: In case of updating the spectrometer firmware, the firmware update is typically delivered on CD or by e-mail. If the firmware update has been delivered on a CD, start the FCONF program directly from the CD by double-clicking on the *fconf.exe* file and proceed as described below. If the firmware update has been delivered via e-mail, first store the delivered files into a temporary directory. Then, proceed as described below.

➢ Thereupon, the following dialog opens:



2. Specify the spectrometer of which the firmware is to be updated. To do this, activate the *Enter custom address* option button and enter the corresponding IP address in dotted notation. (Note: The spectrometer IP address depends on the realized connection variant. For more information, see section 3.10.3.)
3. After having entered the IP address, check whether the intended spectrometer is addressed by clicking on the *Beep* button. The addressed spectrometer will beep shortly three times.
4. Click the *Next* button.

F.3 Updating the spectrometer firmware



1. Activate the *Update firmware* option button.
2. Click on the *Next* button.
3. Select the directory (run folder) in which the backup data are to be stored.

☞ Note: It is recommended to accept the displayed default directory.

4. Follow the next on-screen instructions.

A spectrometer firmware update involves the following steps:

- At first, the FCONF program backs up the current version in case the update-version does not ensure a trouble-free operation so that the firmware needs to be restored again. (For information about how to restore a previous firmware version, see section F.2.)
- Then, the FCONF program updates the current spectrometer firmware version.
- Afterwards, it resets the spectrometer.

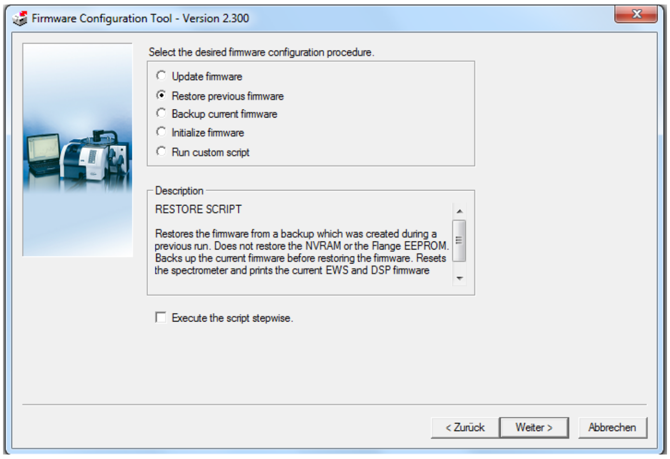
➢ The update procedure may take several minutes, depending on the available bandwidth and the amount of files to be updated.

➢ After the firmware updating has been completed successfully, a corresponding message appears.

➢ In case of error during the update procedure, the FCONF program terminates the procedure and proposes to restore the previous firmware version. (For information about how to restore a previous firmware version, see section F.2.)

F.4 Restoring a previous firmware version

☞ You can restore only a firmware version which has been backed up before.

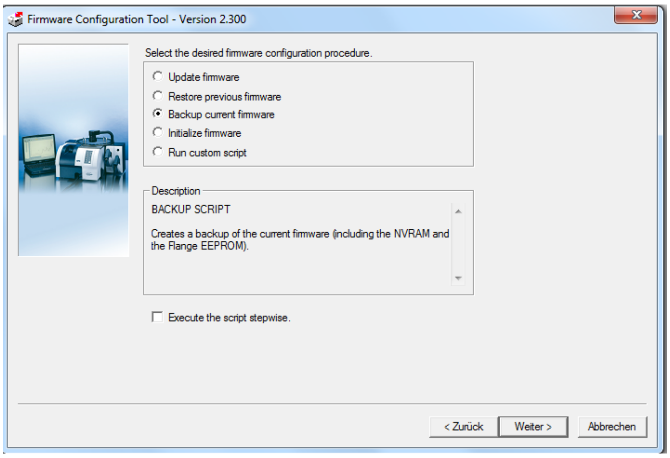


1. Activate the *Restore previous firmware* option button.
2. Click on the *Next* button.
3. Select the directory (run folder) which contains the firmware version you intend to restore.
4. Follow the next on-screen instructions.

Restoring a previous spectrometer firmware version involves the following steps:

- At first, the FCONF program backs up the current version.
- Then, the FCONF program restores the spectrometer firmware on the basis of a previous firmware version which the user has been backed up before.
- Afterwards, it resets the spectrometer.

F.5 Backing up the current spectrometer firmware version



1. Activate the *Backup current firmware* option button.
2. Click on the *Next* button.
3. Follow the on-screen instructions.

G Sample preparation

G.1 General information

Proper sample preparation is crucial to obtain good and meaningful spectra. This section describes several sample preparation techniques that cover a wide range of samples. It will give you some help in choosing the most suitable sample preparation technique for a given sample.

The adequate sample preparation technique depends on the state of aggregation and the spectral absorptivity of the sample. Regardless of the state of aggregation, the sample material has to be homogeneous because variations in concentration or composition within the sample area to be analyzed can result in misleading or erroneous data. Sometimes the trial-and-error procedure is required to obtain an acceptable spectrum.

G.1.1 State of aggregation

Depending on the state of aggregation of the sample, there are different sample preparation and measurement techniques. If you have to analyze a solid sample you can either prepare a solution, a Nujol mull or a KBr pellet. Liquid samples can be analyzed either as a thin film between plates or in a liquid cell. Gaseous samples require dedicated cells with different path lengths.

G.1.2 Absorptivity

The absorptivity of the sample is a critical factor in choosing a suitable sample preparation method. To get a meaningful spectrum of a strongly absorbing sample, the sample has to be either:

- very thin or
- diluted by a solvent or powder that is not strongly absorbing.

According to Lambert Beer's Law, the absorbance (i.e. peak intensity) in an absorbance spectrum is directly proportional to the component concentration in the sample, pathlength of the sample and the absorptivity.

$$A = \varepsilon b C$$

Symbol	Description	Typical measuring units
A	Absorbance at a given wavelength	None
ε	Molar absorptivity (a proportionality constant)	$l \cdot mol^{-1} \cdot cm^{-1}$
b	Pathlength of the sample (cell length for samples in a cell or sample thickness for films, pressed pellets)	cm
C	Component concentration in the sample	mol/l

If the absorbance *A* (i.e. peak intensity) is too strong, decrease the sample concentration *C* by diluting it or diminish the pathlength *b* by reducing the sample thickness. If the absorbance *A* (i.e. peak intensity) is too weak, increase the sample concentration *C* or the pathlength *b* correspondingly to obtain a reasonable peak intensity.

To find out whether a sample is strongly absorbing in the wavelength range of interest or not you have to acquire a test transmission spectrum. Figure G.1 shows a transmission spectrum of a strongly absorbing sample.

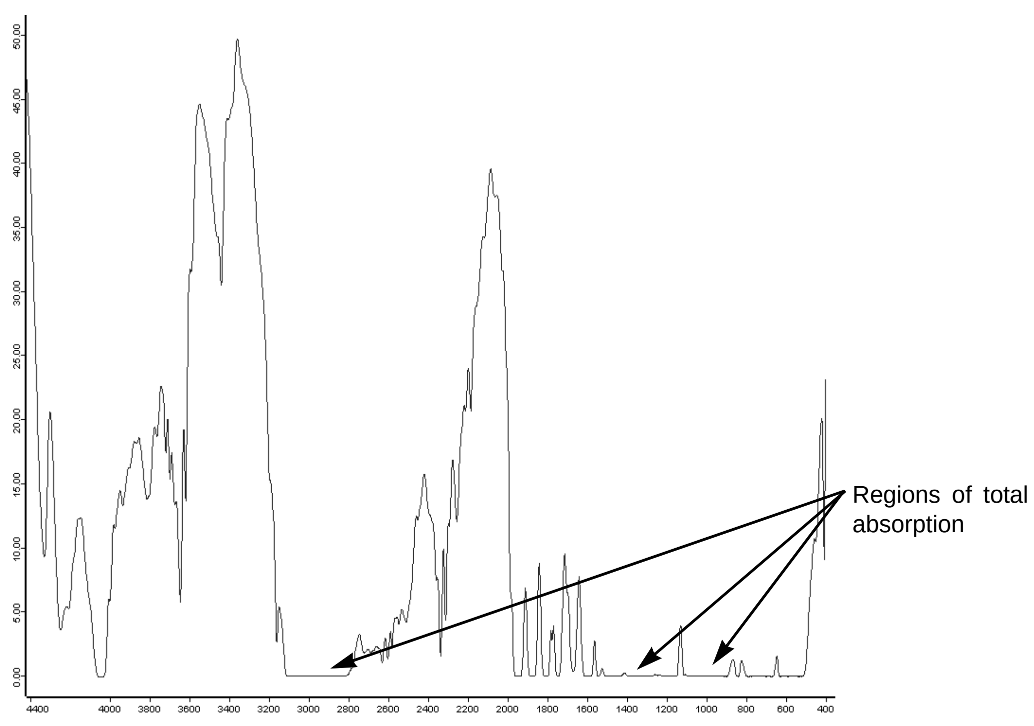


Figure G.1: Transmission spectrum of a strongly absorbing sample

G.2 Sample preparation techniques

There is a large number of possible sample preparation techniques. For lack of space, however, not all possible techniques can be described in detail in this chapter. Therefore, we restrict our explanations only to the most common techniques. (For more detailed information about this topic refer to the relevant specialist literature[1].) Moreover, we give you a general guideline for choosing the adequate sample preparation technique.

To find the most adequate method we recommend trying several sample preparation techniques and acquiring spectral data. On the basis of these data, you can assess which sample preparation technique is the most suitable one for your application. In case of doubt ask your application specialist.

1. e.g. Günzler, Helmut / Gremlich, Hans-Ulrich (2002): IR Spectroscopy - An Introduction. Weinheim: WILEY-VCH Verlag.

Some of the most common sample preparation techniques are:

- No sample preparation (e.g. self supporting film or measurement using a micro-ATR accessory)
- Thin film of liquid sample solution between two IR-transparent plates[1]
- Preparing a sample solution
- Preparing a Nujol mull[2]
- Pressing a KBr pellet
- Liquid cell and gas cell

➢ Most of the described sample preparation techniques involve the use of hygroscopic materials (such as NaCl or KBr), i.e. if these materials come in contact with water or alcoholic solvents, they begin to dissolve or become opaque and thus, impair the measurement results. Therefore, avoid all sources of water and even alcohols (ethanol and methanol).

G.2.1 No sample preparation

The easiest samples to analyze are film and polymer samples with a thickness of less than approx. 100 micrometers. They can be simply placed in a magnetic holder and immediately scanned. The same procedure can be used for samples which can be sliced to an appropriate thickness.

A large number of solid and liquid samples can also be analyzed without requiring a preparation using a micro-ATR accessory. Attenuated Total Reflectance (ATR) units are a very versatile accessory for FT-IR measurements. In many cases, the micro-ATR unit can be used for liquid and semi-liquid materials instead of the constant path transmission cells and the salt plates. In addition, this measurement accessory can also be used for analyzing polymer films, pastes and powders. Due to the reproducible effective pathlength, they are well suited for both qualitative and quantitative analyses. Depending on the sample material and the objective of the analysis, there are different ATR-crystal materials (e.g. ZnS, ZnSe, Ge and diamond). The sample penetration depth ranges between 0.1 and 2µm and depends on the wavelength, the refractive index of the ATR-crystal material and the incidence angle of the beam. (For more information about attenuated total reflectance refer to the respective specialist literature.)

G.2.2 Thin film between plates

Preparing a thin film of a liquid sample between two IR-transparent plates is an easy sample preparation method. Choose this method if your sample is either a liquid or an oil. An advantage of this method is that only a small amount of the sample is required.

- Apply a drop of the sample on one of the plates using a pipet.
- Place a second plate on the top and make a quarter turn to obtain a nice even film of the liquid sample. Sandwich the plates carefully together to remove all air bubbles. Note that these plates are very fragile and can break easily. (The space between the two plates is very small (typically < 0.01mm).
- If the sample amount proved to be too much, separate the plates, wipe one side clean and fit the plates together again.
- Slot the plates in the sample holder of the spectrometer and start the measurement.

1. i.e. IR-transparent within the frequency range of interest
2. A mull is a mixture (more precisely a suspension) of two substances, one of which (i.e. the sample) is finely divided and dispersed in the other (e.g. the paraffin oil Nujol).

➢ The plates (made of NaCl or KBr) are extremely moisture sensitive. Therefore, do not use samples that contain water, keep the plates always dry, clean them only with chloroform or high purity acetone and polish them carefully after each use. In the course of time they will absorb moisture from the atmosphere and deteriorate. Therefore, proper storage (e.g. in an exicator) is extremely important.

G.2.3 Solid sample as sample solution

Use this sample preparation method if your sample is a soluble solid (e.g. a soluble powder). To obtain an IR spectrum, you have to prepare a concentrated solution of your sample using a suitable solvent. The concentration of the solution needed for a good spectrum depends on the sample.

- Dissolve the sample or sample powder in a solvent and apply the sample solution between two support plates, as described above. Depending on the available amount of sample material you can either apply a small amount of your sample powder directly on the plate and add one drop of the solution or dissolve the sample in a test tube and apply the solution with a pipet on the plate.
- A second variant is to apply the sample solution on an IR-transparent plate and allow the solvent to evaporate leaving a thin sample film on the plate. Then, slot the plate in the sample holder of the spectrometer and start the measurement.
- A third variant is to fill the sample solution in a liquid cell and acquire a sample spectrum. To acquire a background spectrum measure the liquid cell containing only the solvent. The volumes of these liquid cells are between 0.1 and 1ml. Microcells with a much lower capacity are also available.
- Do not forget to acquire a background spectrum from the solvent as well.

➢ The plates (made of NaCl or KBr) are extremely moisture sensitive. (See above.)

The major problem in preparing a solution is choosing an appropriate solvent. Most solvents have a strong absorptivity and so their absorption bands will superimpose those of the solute. Therefore, you have to ensure that the used solvent is not strongly absorbing in the wavelength range of interest. Use only spectrophotometrically pure solvents and solvents that are not infrared active in the spectral region of interest.

No solvent is perfect but if some information about the sample is known, the solvent can be chosen accordingly. Commonly used solvents are carbon tetrachloride, carbon disulphide, chloroform, cyclohexane, acetonitrile, and tetrachloroethylene. Never use water as solvent because, firstly, it will dissolve the salt plates and secondly, it exhibits a broad OH-peak. Consult the relevant reference books for the absorptivity of the various solvents.

G.2.4 Preparing a mull

This sample preparation method is suitable if the solid sample can be ground into fine particles but a suitable solvent is not available. In this case the sample powder is suspended in a mulling agent (i.e. a liquid in that the solid is not soluble). A suitable mulling agent is Nujol, a paraffin oil, which is transparent in the infrared region, except for narrow bands at 2900, 1450 and 1375cm^{-1}. (An alternative mulling agent, which does not absorb in these regions, is a perfluorokerosene, such as Fluorolube.)

The advantage of this technique is that it is a relatively quick and simple procedure. The disadvantage is the interference resulting from the absorption bands of the mulling agent. (Both Nujol and Fluorolube have characteristic spectral features and in most cases have to be used as a pair in order to generate a complete MIR spectrum. Nujol is used below 1330cm-1, Fluorolube above 1330cm^{-1}.)

- Put a small amount of your solid sample in an agate mortar.
- Grind the sample thoroughly into fine powder (particles smaller than 500 mesh) using a pestle.

➢ A common mistake when preparing a Nujol mull is to spend too little time grinding the powder. Note that a mull prepared from a coarsely ground solid will yield only a poorly resolved spectrum. Grinding the sample into very fine particles is also important to reduce light scattering and salt plate scratching.

- Add 1 or 2 drops of Nujol. Be careful not to add too much Nujol.
- Mix the ground sample with the mulling agent until a uniform paste with a vaseline-like consistency is formed.
- Apply some mull on the surface of a NaCl plate using a suitable tool (e.g. a small spatula or a rubber policeman). Be careful not to scratch the plate.
- Place the second plate over the mull. To ensure an even and thin sample thickness between the plates, rotate and press the plates together in order to squeeze out the excess of the paste. Exclude also air bubbles.
- Slot the plates in the plate holder installed in the spectrometer sample compartment and start the measurement.
- Do not forget to acquire also a background spectrum of the pur Nujol.

G.2.5 Pressing a KBr pellet

This sample preparation technique is very suitable for solid samples in terms of the information yield from an IR spectrum because KBr is significantly more IR transparent than most solvents or Nujol oil. KBr has no absorption in the region 4000cm^{-1} to 250cm^{-1} so that a good sample spectrum (i.e. a spectrum that does not contain spectral information about the dispersing agent) is obtained.

The success of this technique strongly depends on the grain size of the ground sample. Grind the sample as fine as possible (particle size of at least 200 mesh, better 500 mesh) to minimize the infrared light scattering on the particle surface, also called Christiansen effect. This effect is caused by a refraction index mismatch between the salt (KBr) and the sample powder that leads to reflections at the salt-sample interface. Therefore, proper grinding is required to ensure a good contact between KBr and sample powder and to minimize the portion of the reflected light.

Another important factor in this technique is to keep everything moisture free as the KBr material is hygroscopic. To prevent the KBr material from absorbing moisture, keep the KBr material and the die in a drying oven at a temperature of 50 to 60°C. Failure to do so will result in opaque pellets that yield distorted spectra. A correctly prepared KBr pellet will be transparent to IR light.

To sum it up, the KBr-pellet technique yields good quality spectra with a wide spectral range and no interfering peaks. Disadvantages include tedious and time consuming sample preparation and cleanup, interference of water bands (3,960 to 3,480cm^{-1} and 1,950 to 1,300cm^{-1} and below 500cm^{-1}) and in same cases structural changes caused by high pressure applied to the KBr/sample mix.

- Put a small amount of the sample in an agate mortar and grind it up as fine as possible.
- Add a spatula full of oven-dry KBr material to the ground sample and mix it until a uniform mixture is obtained. Do not grind the mixture as this may increase the absorption of water by KBr.

➢ A common mistake is to use to much sample. The concentration of the sample in KBr should be in the range of 0.2% to 1% (i.e. typically a 300:1 dilution by mass).

- Transfer the mixture into a die of a hydraulic or hand press and subject it to very high pressure (ca. 20,000 psi) for a few minutes (2 to 5 minutes). The result should be a translucent pellet with an ideal thickness of 0.5 to 1mm.
- Carefully remove the pellet from the die, place it in the pellet holder and put the pellet holder in the spectrometer sample compartment.

➢ The KBr pellet is very hygroscopic and fragile. Handle it with care and use gloves to avoid contact with moisture from your hands. Measure the KBr pellet immediately after removing it from the press as the pellet will fairly rapidly begin to absorb moisture from the air and becomes opaque.

G.2.6 Liquid cell

Liquid cells produce excellent results for most liquids. Especially for liquid samples that are very volatile, using a liquid cell is highly recommended. A liquid cell consists of two IR transparent windows with a precision spacer in between. One of the windows has two drilled holes for the introduction and evacuation of the liquid. A large number of cell options are available including permanently sealed cells, demountable cells with different window material and a wide selection of spacers.

➢ Take into consideration that KBr is hygroscopic and the pathlength of the KBr cell will change when exposed to a ‘wet’ sample (this may affect quantitative results). In addition, water will reduce the cell throughput by clouding the windows. Note that many liquid cells contribute a fringe pattern to the spectrum. Matching the refraction index of the window material with that of the sample can minimize this effect.

G.2.7 Gas cell

To obtain an infrared spectrum of a gaseous sample a gas cell with windows at each end is required. It is important to select a suitable window material (e.g. KBr, NaCl, or CaF_2) that does not absorb infrared light. The cell usually has an inlet and outlet port with a tap to facilitate the filling with the gas to be analyzed. Simple demountable cells (50 mm to 100 mm) are recommended for samples in a 5 - 10% concentration range. For diluted samples (ppm to ppb concentrations) a long path cell should be used. The long path cell reflects the IR beam several times through the sample using a set of mirrors positioned on the opposite ends of the cell. Note that the cell thickness, the pressure of the gas (proportional to concentration) inside the cell, and the molar absorptivity determine the peak intensity.

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EC-DECLARATION OF CONFORMITY

The undersigned, representing the following manufacturer

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

herewith declares that the product

Product identification: **Vertex 80v**

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

Reference no.	Title
73/23/EWG	Directive of the commission from February 19th, 1973 (Low Voltage Directive)
2004/108/EG	Directive of the commission from December 15th, 2004 (Electromagnetic Interference Directive)
93/68/EWG	Directive of the commission from July 22nd, 1993 (Amendment Low Voltage Directive)

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

Last two digits of the year in which the CE marking was affixed: 06
(when compliance with the provisions of the Low Voltage Directive 73/23/EWG is declared)

Ettlingen .... June 20, 2006 ....
(Place) (Date)

....
(Signature)

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

Page 1 of 2 of EC-Declaration of Conformity of **Vertex 80v**

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

Harmonized standards:

No.	Issue	Title	Parts(1)
EN 61326:1997 +A1:1998+A2:2001+ A3:2003	Mai 2004	Electrical equipment for measurement, control and laboratory use – EMC requirements	
EN 61000-3-2:2000 +A2:2005	September 2005	Electromagnetic compatibility; Part 3-2: Limits - Limits for harmonic current emissions	3-2
EN 61000-3-3:1995 +A1:2001+A2:2005	June 2006	Electromagnetic compatibility; Part 3-3: Limits - Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current ≤16A	3-3
EN 61010-1:2001 (2nd Edition)	August 2002	Safety requirements for electrical equip-ment for measurement, control and labor-atory use; Part 1: General requirements	1
EN 60825-1:1994+ A1:2002 + A2:2001	October 2003	Safety of laser products; Part 1: Equipment classification, requirements and user`s guide	1

Other standards and/or technical specifications:

No.	Issue	Title	Parts (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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