Installation and Maintenance Guide

Setup, Operation, Maintenance of
RPG standard single-polarization radiometers

Applicable for
HATPRO, LHATPRO, TEMPRO, HUMPRO, LHUMPRO,
LWP, LWP-U90, LWP-U72-82, LWP-90-150,
Tau-225, Tau-225-350

Document Change Log

Date	Issue/Rev	Change
07.07.2011	00/01	Work
20.07.2011	01/00	Release
15.12.2011	01/01	description of weather station installation added (2.6.5)
20.12.2011	01/02	description of new 2-line fiber connector system added (2.7.4)
17.04.2014	01/03	changes in packing materials
23.03.2015	01/04	Mounting procedure for new IRR housing added
12.08.2016	01/05	Update to G5
11.11.2017	01/06	Update to safety instructions
29.01.2018	01/07	Update to safety instructions and Voltage ratings etc.
20.02.2018	01/08	Adapted temperature ranges
09.01.2019	01/09	Radiation susceptibility: upper limit for external radiation field strength added to safety requirements
29.10.2019	01/10	Updated picture and text to match latest design modifications
24.03.2020	01/11	PTU exchange of the Vaisala weather station included
20.05.2021	01/12	IR wiring with 90° connector cable
05.07.2021	01/13	Text revisions and updated pictures. Calibration section updated for the PT-V2 target.
28.06.2022	01/14	Update Safety Instructions and Warnings
22.08.2022	01/15	Revision Spare part list
19.05.2023	01/16	Added drawings of radiometer and stand dimensions

Table of Contents

Safety Instructions and Warnings

Instrument Use

The RPG-HATPRO series of instruments are microwave detectors for measuring humidity, temperature, and liquid water profiles in the earth's troposphere. Given the sensitivity to these profiles, the RPG-HATPRO systems are capable of retrieving also tropospheric attenuation, wet and dry delay, and the atmospheric stability indices. The radiometer is a purely passive instrument (only detection), measuring the sky brightness temperatures at frequencies of atmospheric water vapour and oxygen spectral lines as well as window channels between those lines. Apart from humidity and temperature profiles the system also determines integrated quantities like integrated water vapour and liquid water path in the troposphere. The instrument is intended for providing information needed to improve numerical weather forecasts and for climatology studies in climate research. The radiometer should only be used for the purpose described here.

Before Starting Operation

Read these instructions carefully. They contain important notes for the use, safety and maintenance of the instrument. Make sure that all persons involved in the installation and maintenance of this hardware have read the content of this document and have access to it any time.

Only use the instrument for the purpose mentioned in these instructions.
Before powering up any part of the hardware, it is important to consider guidelines for safe operation (meaning the instrument as well as the operators). In addition to the guidelines given here, the user should use **common sense** precautions to prevent damages to personnel and equipment.

The described hardware is intended for **outdoor use** only.

To avoid damages due to water condensation, the instrument **must be powered on** when deployed outdoor. If for any reason the instrument cannot be powered on, then store it indoor.

The instrument itself does not emit microwave radiation, but some accessories, like certain types of weather stations attached to the instrument, are equipped with low power rain radar sensors (operated at 24 GHz, power emission 1 mW) that may disturb other high frequency equipment close to the instrument. When operated outside of buildings, this possible interference is considered to be negligible.

All microwave radiometers are operated with external heater modules generating **up to 2 kW of heating power**. **Therefore, operation of heater modules inside buildings is absolutely prohibited, even if attended. The user is responsible for any damage caused by the operation of heater modules inside of buildings**.

Heater modules have a limited lifetime of about 4 years and must be replaced after this period.
The heater air inlet must never be blocked by obstacles, for instance tape, snow, etc.

The instrument may be operated in combination with a powerful azimuth turn table. Such instruments conduct an automatic reference drive after the main switch has been turned to the ON position: The instrument will perform a 360° counter-clockwise rotation, about 1 minute after switching it on. **Please leave the danger zone around the instrument (1 m radius) right after turning the main switch to the ON position.**

Instruments equipped with an azimuth turn table may rotate any time during operations. In order to mitigate the risk of injuries caused by the rotating instrument, it is required to install a protection fence around the instrument (1 m minimum radius).

This instrument is not intended to be used or installed by children or persons with physical or mental disabilities or who lack experience or have not been supervised by persons responsible for their safety.

Before powering the instrument, make sure that all power cables and inter-connecting cables to accessory hardware (for instance weather station, GPS clock, azimuth turn table, IR radiometer) are **completely and properly** installed, according to the instructions described in the following paragraphs.

Installation Related Technical Data

The instrument should be handled with the same care as other electronic equipment. The radiometer shall be protected from fire, over voltages (caused by lightning or malfunctions within electric power networks), falling/flying objects (debris during hurricanes, typhoons, and tornados), physical forces, shock and vibration at levels which would be harmful to computer hardware or other sensitive electronic equipment.

The instrument is classified to **protection class IP44**.

Do not store the radiometer hardware outdoors unprotected. Once installed, keep the radiometer switched on. You may only switch off the radiometer for short time periods, e.g. during maintenance.

The safe environmental parameters for **transport and storage** are:

Parameter	Range
Temperature	-30 °C to +45 °C
Humidity	non-condensing
Pressure	300 hPa to 1300 hPa (mbar)
Vibration	< 10 g acceleration
Shock	< 20 g acceleration

Make sure that the **radiometer is only switched on**, when the environmental temperature is **above the minimum storage temperature**.

The safe environmental parameters for **operation** are:

Parameter	Range
Temperature	-30 °C to +45 °C
Humidity	1% to 100% relative humidity
Pressure	300 hPa to 1300 hPa (mbar)
Vibration	< 1 g acceleration
Shock	< 10 g acceleration

Power line requirements:

Parameter	Range
Voltage	100-230 V ~, 50 to 60 Hz
Power consumptions AC 1 (100 – 230 V ~)	Instrument: <120 W average, 650 W during warm up Blower: 130 W maximum
Power consumptions AC 2 (230 V ~)	Heater Module: 2 kW @ 230 V/AC 500 W @ 110 V/AC (transformer to 230 V/AC required for full power operation)

- **Only use the delivered power cable and plugs.**
- Maximum altitude for operate the instrument is 2000 m. Above 2000 m, surge arresters must be installed on site.
- The connector must not be connected or separated under load.
- Connect the power cable only to a shock- and water-proof socket that has been installed according to the local regulations by skilled technical personnel.
- For lightning protection, the use of **surge breakers** is strongly recommended. **Any damage to the instrument or its accessory hardware caused by lightning is not covered by RPG warranty!**
- Do not pull the power cables over sharp edges. Cables must be protected from heat and oil.
- Do not pull the power plugs by the cable or touch them with wet hands. The power plugs must be kept dry under all conditions.
- Unplug the equipment immediately from power supply if the instrument or power cable / plugs appear to be damaged.
- Turn off the instrument (ON/OFF switch) when connecting/disconnecting GPS-clock, weather station, azimuth turn table or heater module to/from the instrument.
- Run the blue power cable via a UPS (unbreakable power supply, 100 to 240 V /AC) and connect the yellow power cable directly to a separate 220V / AC (use a 110 to 220 AC transformer in countries with 110 V / AC power lines).

When installing the radiometer, **make sure the power connectors are plugged into power sockets with proper grounding pins (PE = protection earth) connected to protection earth potential**. Otherwise, the instrument parts are electrically floating and the instrument may get more easily hit by lightning strokes.

If the PE pins of the power sockets are not properly connected to protection earth, the user may be exposed to electrical shock when touching the instrument.

Any malfunctions and failures arising from operating the radiometer and its accessories (including cables and controlling host PC) outside of the specified environmental conditions, are not covered by the instrument warranty. Damages (and consequential damages) from either violating the instruments physical and electrical integrity, or arising from third parties (including animals, e.g. bird attack to the microwave window) are not covered by the instrument's warranty.

Instrument weight and dimensions:

Parameter	Range
Weight	Radiometer: approx. 65 kg without blower and heater module Blower: approx.12 kg Heater Module: approx. 5 kg
Dimensions	63 × 36 × 90cm^3

Because of the instrument weight of approx. 65 kg, it must be lifted by at least **four** people (adult persons with no physical or mental disabilities) when unpacking or lifting it on the instrument fixed table or turn table. The instrument is delivered with four handles close to the bottom of the housing and each handle should be used by one person.

Safety Instructions for Handling Liquid Nitrogen

For performing absolute instrument calibrations, it is required to handle liquid nitrogen (LN2). The boiling temperature of this liquid is about -196°C at 1000 mbar barometric pressure. Therefore, in order to prevent serious injuries when touching LN2 with naked skin the following precautions must be followed:

All persons handling LN2

- shall be trained in the handling of LN2
- shall wear suitable protective gloves
- shall wear protective glasses / goggles
- shall wear a protective apron
- shall follow the general safety guidelines for handling cryogenic liquids

Failures to comply with these safety measures may result in freezing injuries from the cold LN2 temperature.

The following list of safety instructions must be followed when using the PT-V1 or PT-V2 calibration target delivered with the instrument:

- Perform a visual inspection of the target central seam line **before filling it with LN2**. If the seam is damaged to a depth of more than 4 mm (open seam), the target must not be used and has to be replaced (risk of LN2-leakage).
- The target maximum upper LN2 filling is 3 cm below the container's inner upper end level. If the target is filled to its maximum end level, there is a significant risk of LN2 spill out of the target during target transportation.
- After target filling, mount the top target lid and fasten it with the four rubber locks. Without the target lid, there is a risk of LN2 spill out of the target during transportation.
- The maximum target filling count is limited to 30 fillings total. Replace the target if this number is exceeded. Otherwise there is a risk of LN2 leakage.
- Store the target in a dry and dark place (no UV or direct sun light!). Otherwise, the target foam material can develop cracks which may cause a LN2 leakage even before the maximum number of fillings (30) is reached.

Precautions During Azimuth and IRR Stepper Operation

In addition to the normal common-sense precautions when handling electric equipment and heavy equipment, the user needs to avoid injuries from moving parts.

If the instrument is equipped with the optional azimuth positioner, which allows rotating the whole instrument from 0° to 360°, all persons should stay away from the radiometer by at least one meter. This safety distance should be ensured by the installation of a warning fence as described above.

When servicing the instrument (for instance during maintenance activities), electric power should be turned off or attention must be paid for keeping fingers and hands away from the azimuth turn table and Infrared Radiometer drive. Otherwise fingers may get clamped or squeezed.

System Performance

The radiometer is a highly sensitive detector for microwave radiation originated from earth's atmosphere. The radiometer's detection performance may be reduced if external radiation [10 MHz to 1 GHz] of higher than 3.0 V/m is present. Spurious response (spikes) on the brightness temperature time series may be caused by immanent radiation above the specified field strength.

Spare Parts

If any hardware of the instrument or its accessories, as well as inter-connecting cables or power cables need to be replaced due to damage or general maintenance intervals, **only original spare parts provided by RPG must be used**. No reliability is taken for any direct damages to the instrument and its accessories or indirect damages to the instrument's environment caused by using hardware not fabricated or delivered originally by RPG.

Further Information

If further technical support is required, please contact:

Radiometer physics GmbH
Werner-von-Siemens-Str.4
53340 Meckenheim/Germany

Tel: +49-2225-99981-0

e-mail: remotesensing- service@radiometer-physics.de

2 Setup and Installation

This chapter covers the complete installation of the radiometer up to the point of starting operations.

2.1 Deployment Recommendations

The location for a radiometer installation needs to comply with several requirements in order to guarantee successful recording of valid data. The following list of requirements shall be matched:

- Flat and stable grounds to support 100 kg of weight (plus personnel), preferably a concrete base plate or a flat rooftop.
  - If vegetation covered soil or bare soil is chosen, then some extra provision is needed to prevent the radiometer stand from sinking into the ground.
  - If the surface does not allow the mounting of steel cables to tie the radiometer to the ground, then the radiometer stand needs to be loaded with extra weight
- The view to the horizon should be unobstructed by trees, fences, and buildings into at least one direction (for radiometers without azimuth positioner it needs to coincide with the main scan direction indicated by the orange arrows on the housing).
- For sky scanning, a significant distance from obstacles like houses and trees is beneficial.
- The distance from the radiometer to (a) power outlets and (b) the location of the controlling host PC should match the length of the cables ordered with the radiometer
- A safe routing option for the cables (outdoor indoor) should exist. The power cable diameter is 12 mm, the data cable is a fiber optical cable which needs to be handled with great care. Pushing and pulling the cables can lead to a malfunction of the cable performance.
- To avoid in-band RFI, the user may want to check for radars and telecommunication links directly in the observation bands (22 GHz to 32 GHz, and 51 GHz to 59 GHz).

2.2 Unpacking the radiometer and accessories

The following standard components are delivered in addition to the radiometer:

- Instrument stand with adjustable feet
- External absolute calibration target (cold load)
- Connector caps
- Interconnecting cables (main power, fiber optics data interface cable), 50 m long (default)
- Powerful dew blower system + heater module
- USB drive with complete host software folder for easy software installation on the host PC
- An optional infrared radiometer
- An optional azimuth positioner

2.2.1 Radiometer Box

The radiometer system is shipped in up to four flight cases. One contains the radiometer itself (Fig.2.2.1) while the others contains all the accessories needed to operate and calibrate the instrument. The radiometer case is fastened to the container by two straps as indicated in Fig.2.2.1. The GPS-clock is not disassembled from the radiometer for packing.

Fig.2.2.1: Radiometer packed to the transport container's base plate.

2.2.2 Accessories

Fig.2.2.2: Accessory boxes with radiometer stand, calibration target, heater module, cables, IR Radiometer and azimuth drive.

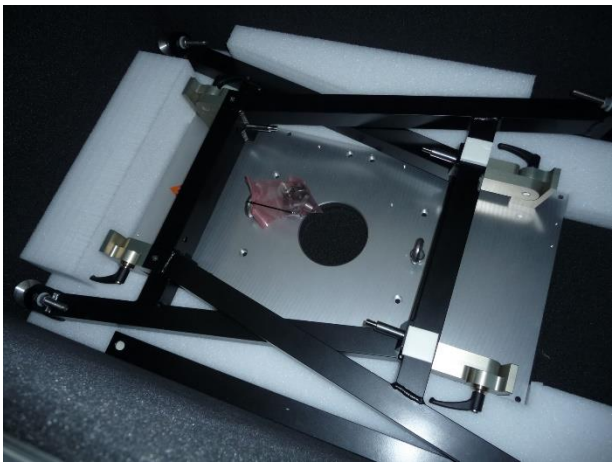
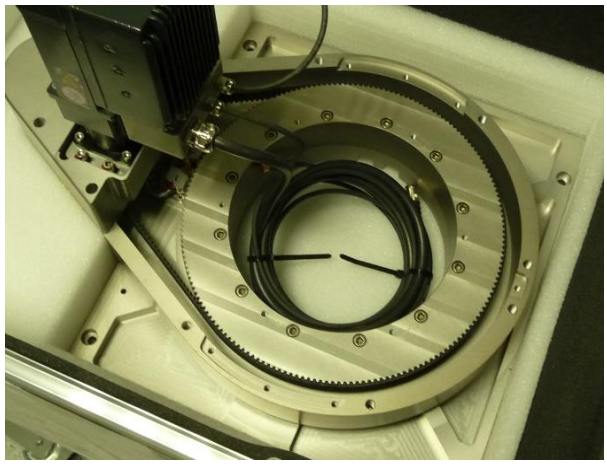




Fig.2.2.3: Folded stand and azimuth turn table both packed to their container. The toolbox includes all the tools needed to assemble, disassemble, and maintain RPG radiometers.

2.3 Setup the Instrument Stand

The instrument stand is packed folded with the four feet mounted to the stand's legs.
Lay the folded stand on the top side of the table plate (Fig.2.3.1). Lay the stand on a soft surface or use a mat or something similar to prevent the table surface from being scratched.

The two leg pairs are clamped by two clamps with black steel handles each. Open the clamps to turn the two leg pairs into upright position. The clamps can be pulled and turned to facilitate their use. The leg pairs should be pushed outside as much as possible (see Fig.2.3.2b)). Then fasten the clamps firmly (Fig.2.3.2a)) and turn the stand to its normal orientation, with the table surface pointing upwards.

Unpack the two black stabilizing bars (Fig.2.3.3a)) and the four mounting nuts (Fig.2.3.3b)). Then push the two bars onto the stand's cross-beam threaded bolts as in Fig.2.3.4a) and fasten them with four special nuts (Fig.2.3.4b)). There are no special tools needed to set up the stand.

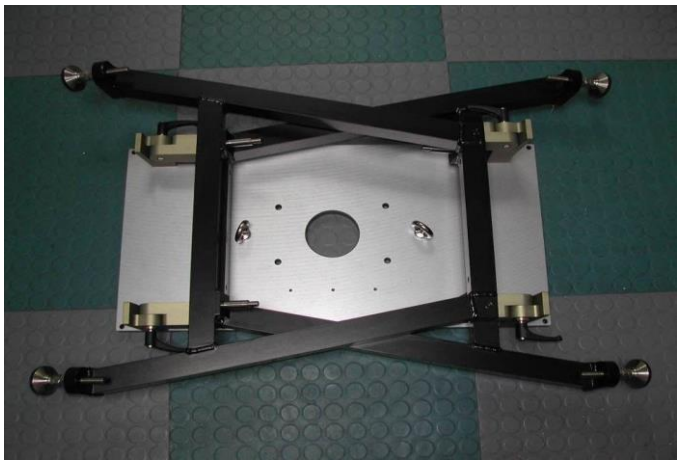


Fig.2.3.1: The folded stand.

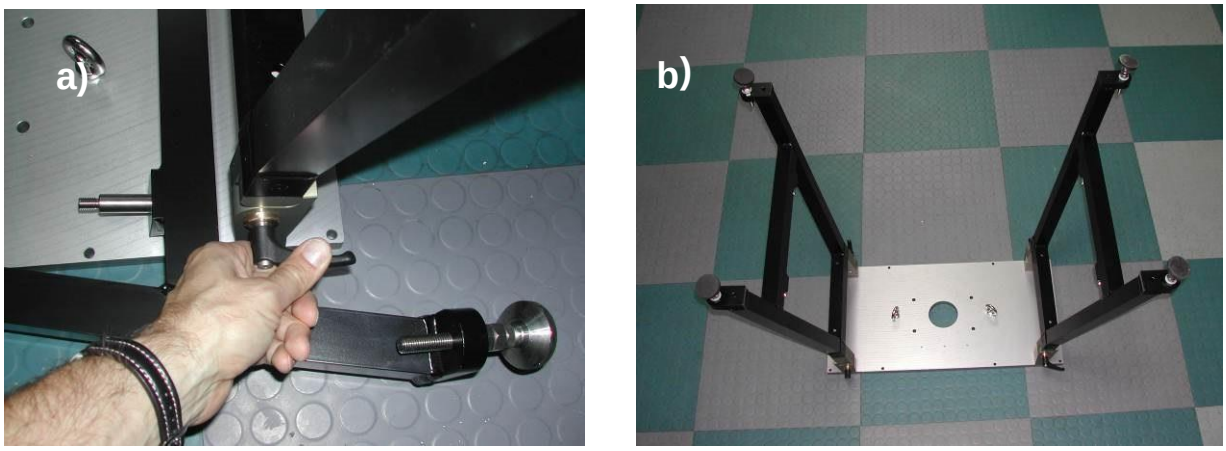


Fig.2.3.2: Open clamps and turning legs into upright position.

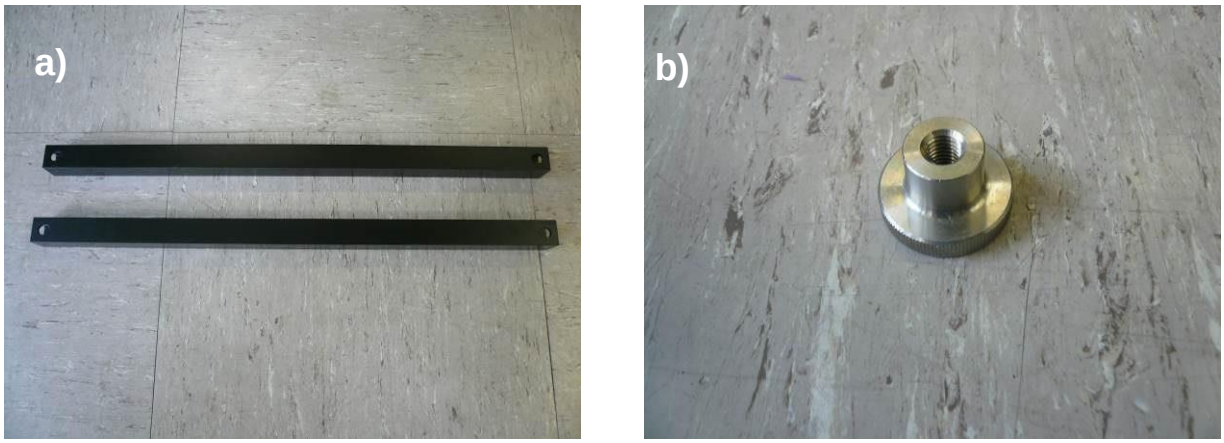


Fig.2.3.3: Stabilizer bars and mounting nuts.

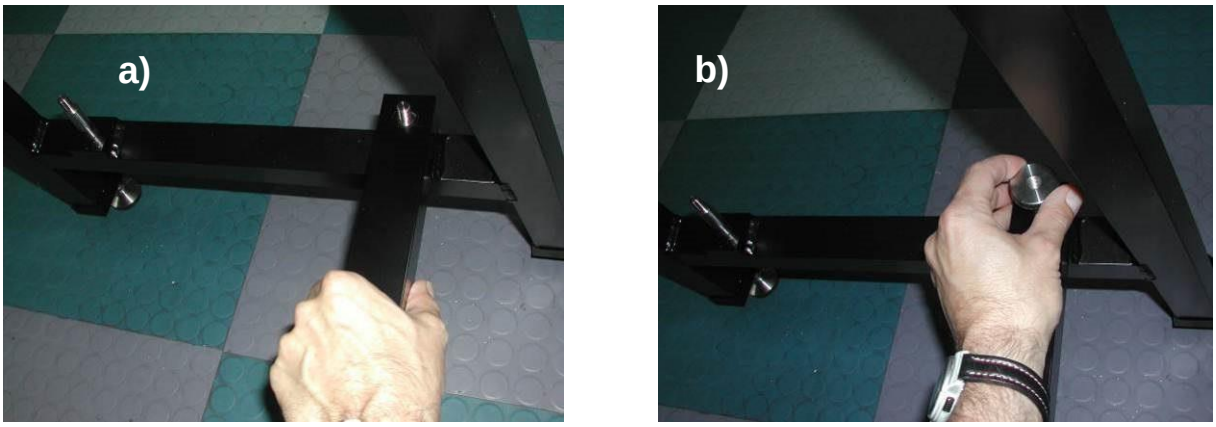


Fig.2.3.4: Mounting the horizontal stabilizer bars.

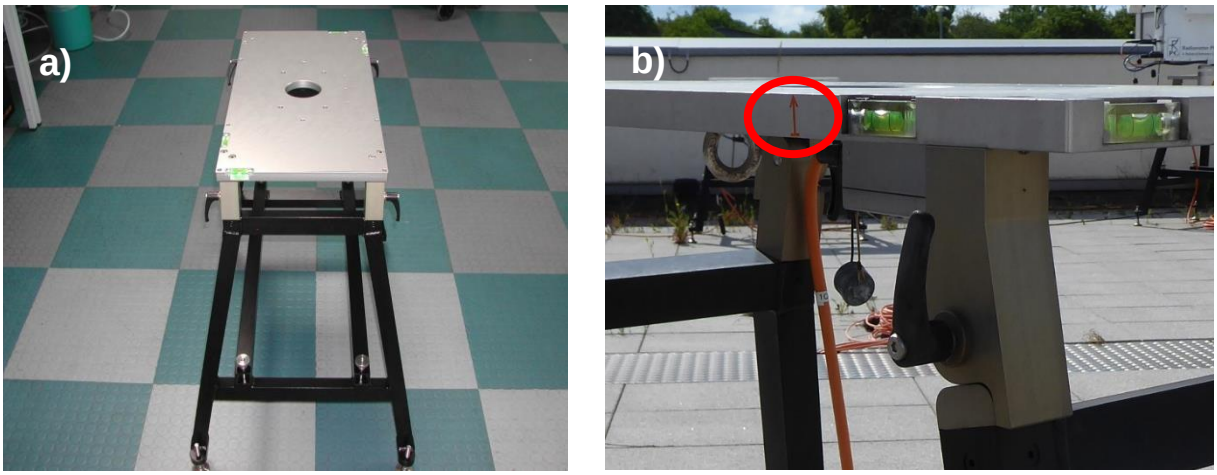


Fig.2.3.5: Completely mounted stand. The red arrow on the stand side is highlighted by the red circle

If the radiometer has the **optional azimuth drive**, the stand needs to be North aligned: the side of the radiometer stand with a red arrow (Fig.2.3.5b) need to be facing the geographical North. Use a compass for a coarse orientation of the stand; a refined orientation will be achieved using a software feature, which make use of the sun position to achieve an orientation with accuracy of 0.1 degrees. **Do not** fix the stand to the ground until North alignment has been performed.

Finally, the stand should be horizontally aligned. For this purpose, 4 spirit levels are located on the table plate's edges (Fig.2.3.6a)). Loosen the upper nut and adjust the feet as indicated in Fig.2.3.6) for horizontal alignment. In case the radiometer has the **optional azimuth drive,** only a coarse horizontal alignment is necessary, a refined horizontal alignment shall be performed only after a refined North alignment is achieved.

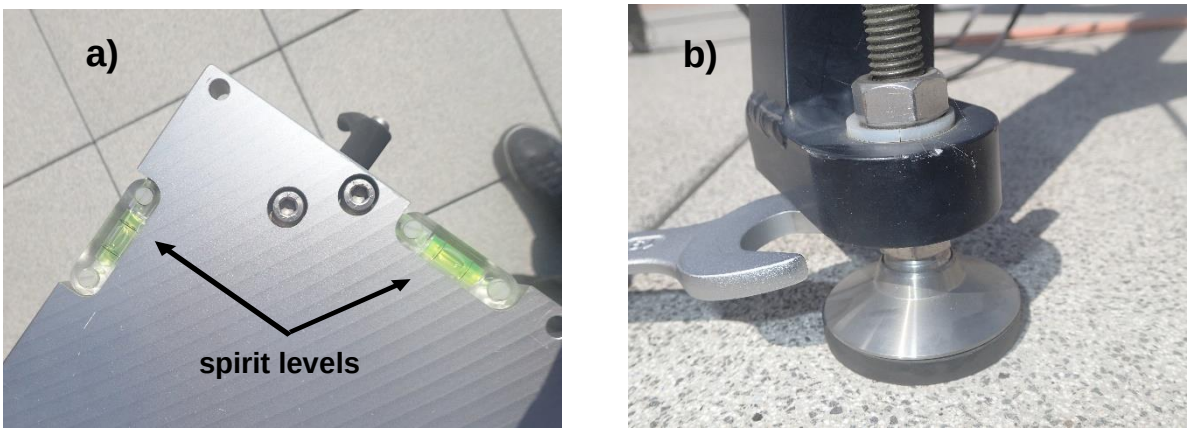


Fig.2.3.6: Spirit levels on table base plate for horizontal adjustment of the stand.

Without this adjustment, the reading of the elevation axis during measurements is not equivalent to the real observation elevation angle. The inclination angles of the elevation axis and the direction normal to it are adjusted by inspecting the spirit levels attached to the stand's table and changing the stand's 4 individual feet lengths (M19 wrench required).

2.4 Setup of the Azimuth Positioner (Optional)

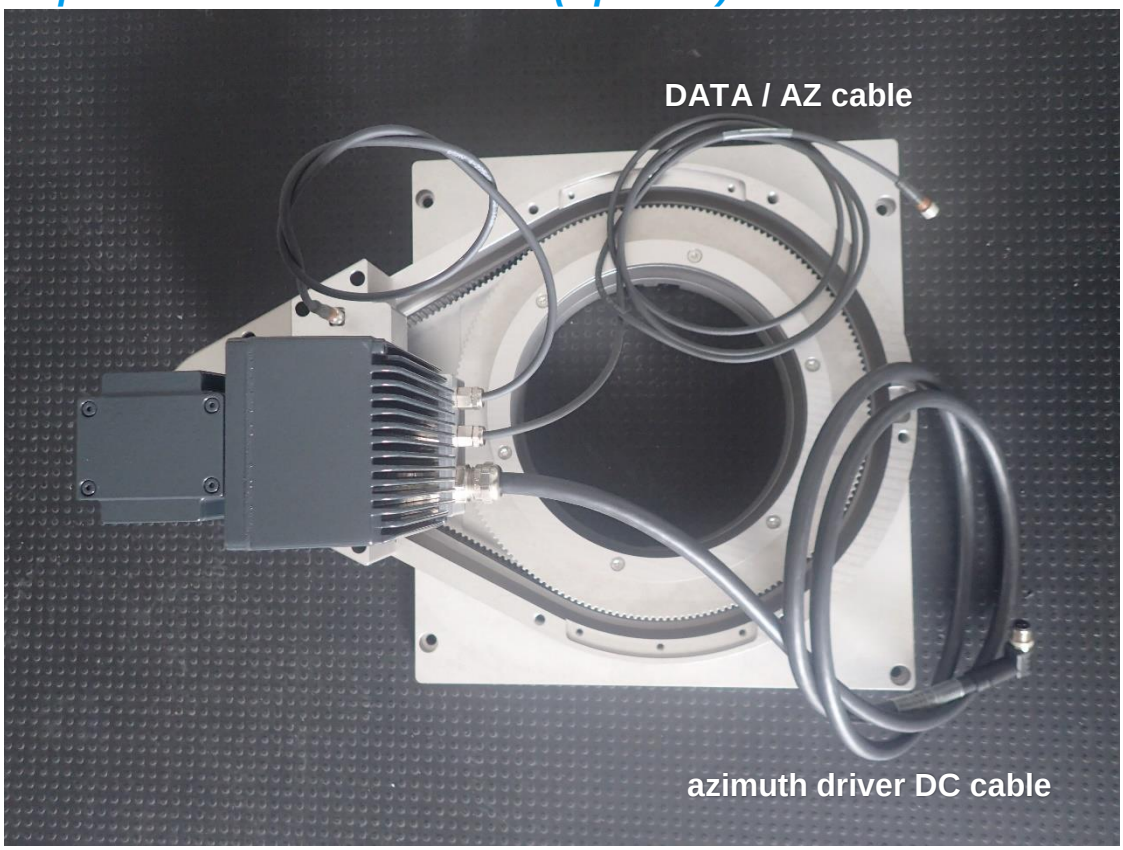


Fig. 2.4.1.: Azimuth positioner

The azimuth positioner is an optional equipment which is required when the radiometer shall perform full sky scanning or other scanning patterns.

After unpacking the azimuth drive and laying it on its table plate, the sub-unit looks like in Fig.2.4.1. Two cables are important for the later installation steps: The driver's DC power cable (thick black cable) and the controller's cable (thin black cable), labelled 'DATA / AZ'. When the azimuth drive is mounted on top of the stand, it is important that the two red arrows are located on the same side, as indicated in Fig.2.4.2.
Fix the azimuth drive with 6 screws (M8, 25 mm thread length) from the bottom side of the stand's plate (see Fig.2.4.3).

Fig.2.4.2: Azimuth positioner on the stand's table plate.

Fig.2.4.3: Fixing the azimuth drive with 6 M8x25 screws.

Fix the power splitter unit (Fig. 2.4.4.) with 4 screws (M5, 14 mm thread length) to the bottom side of the stand's plate as shown in Fig. 2.4.4.

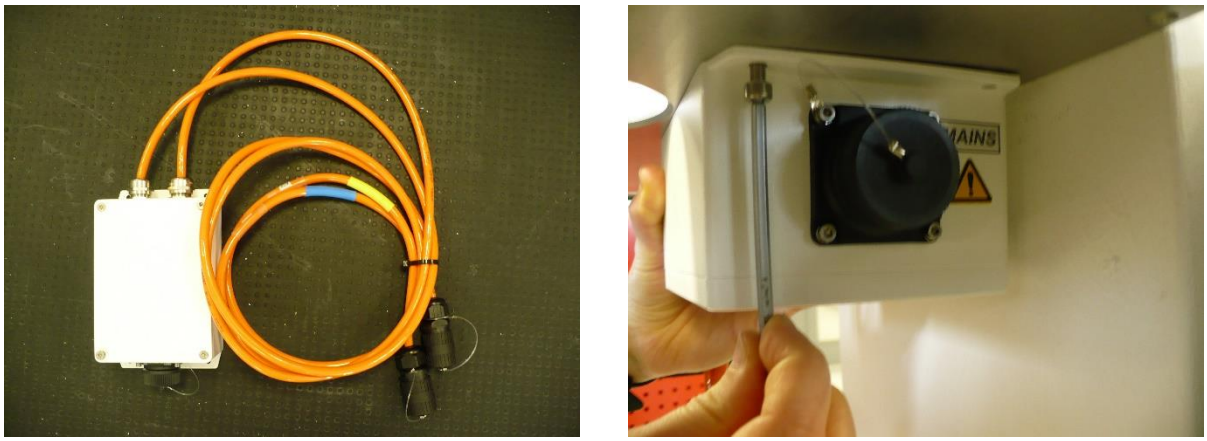


Fig. 2.4.4.: Fixing the power splitter unit to the bottom side of the stand with 4 M5x14 screws.

Unscrew the black plastic brackets (Fig.2.4.5) on the top of the azimuth table. The cable channels are labeled with the cable designations as shown in Fig.2.4.6a),b).

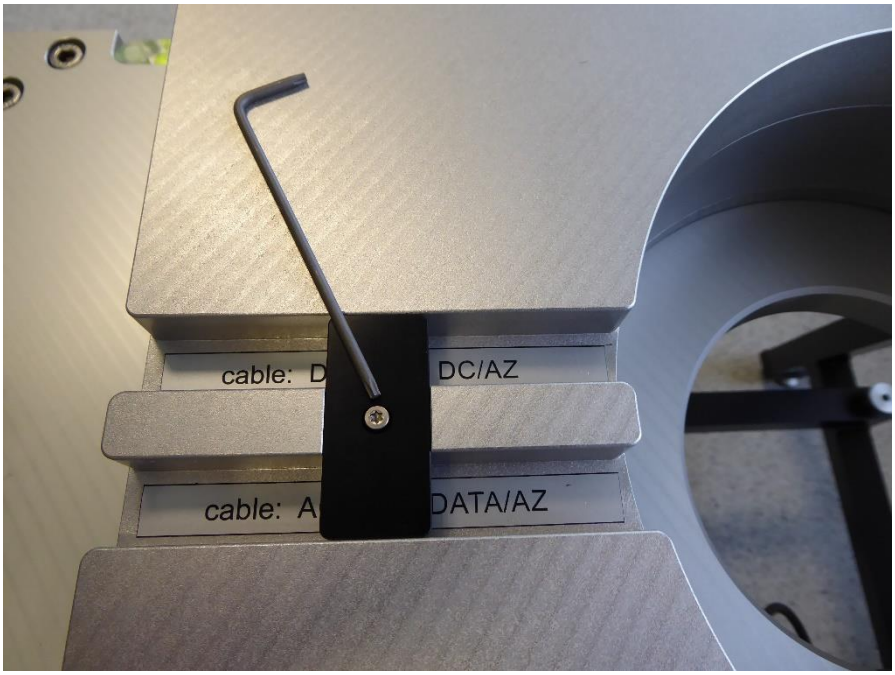


Fig.2.4.5: Plastic brackets on cable channels.

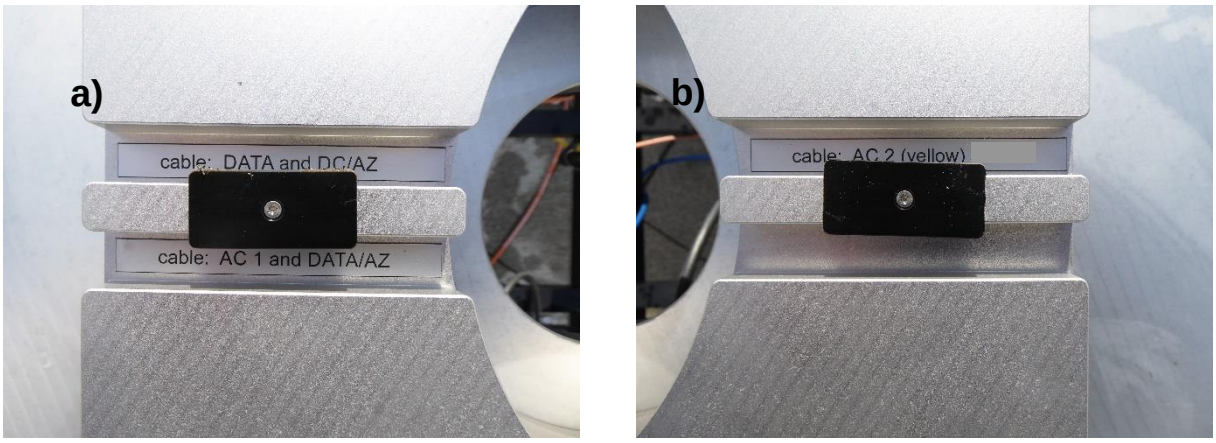


Fig.2.4.6: Labeled cable channels for a): AC1 cable, DATA/AZ cable, fiber optics DATA cable and DC/AZ cable and b): AC2.

Now feed the AC1 cable (blue or blue labelled), AC2 cable (yellow or yellow labelled), the DATA/AZ cable (black), the fiber optics data cable and the DC/AZ cable through the central azimuth drive hole as shown in Fig. 2.4.7.

Fig. 2.4.7. Feeding the cables through center hole. Do it for AC1, AC2, DATA/AZ, fiber optic DATA, and DC/AZ.

Thread the different cables into their associated channels and mount the black plastic brackets (Fig.2.4.8).

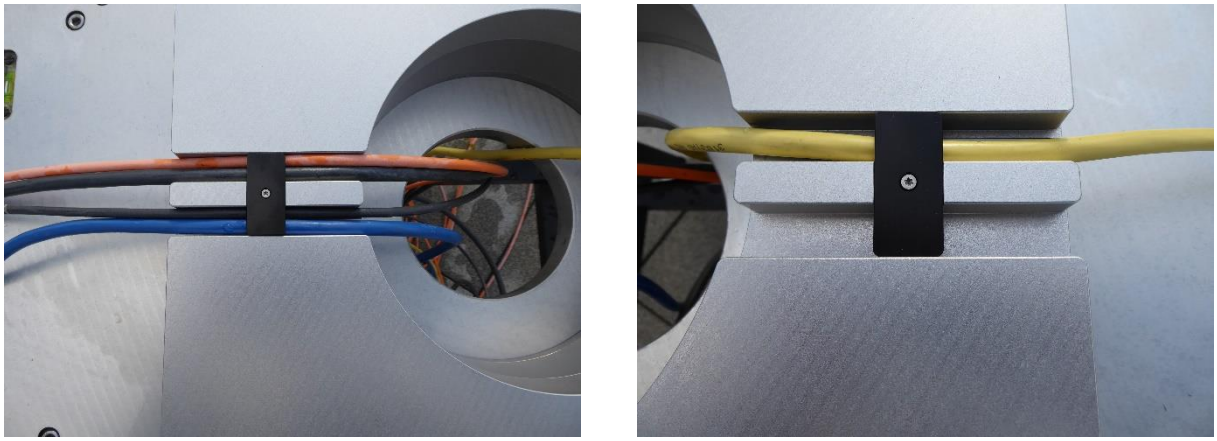


Fig.2.4.8: Mounting the cables into the cable channels.

2.5 Mounting of Radiometer Box

Only in case the radiometer is directly mounted to the stand without azimuth positioner, the 2 black cones provided with the stand shall be mounted as shown in Fig. 2.5.1.

Fig.2.5.1: Black cones to be mounted only in case of no azimuth positioner

After the installation and adjustment of the instrument stand and optional azimuth positioner, use the handles to lift the radiometer box on the azimuth table (Fig.2.5.2) if the optional azimuth drive is installed, or directly on the stand's top plate, if no azimuth positioner is used. The radiometer box has to be oriented, so that all red arrows are on the same side. Whenever lifting the radiometer box, the dew blower must be removed from the radiometer before (see section 2.6.1).

To fix the radiometer box to the azimuth table or directly to the stand, four M8 screws (25 mm thread length) are used (Fig. 2.5.3).

Before connecting the AC1, DATA/AZ, DC/AZ and fiber optics cable, the connector socket protection caps must be removed. Keep these protection caps for future use: if a socket is left unprotected during transportation, condensation water may accumulate inside the connector, which may lead to malfunctioning of the radiometer.

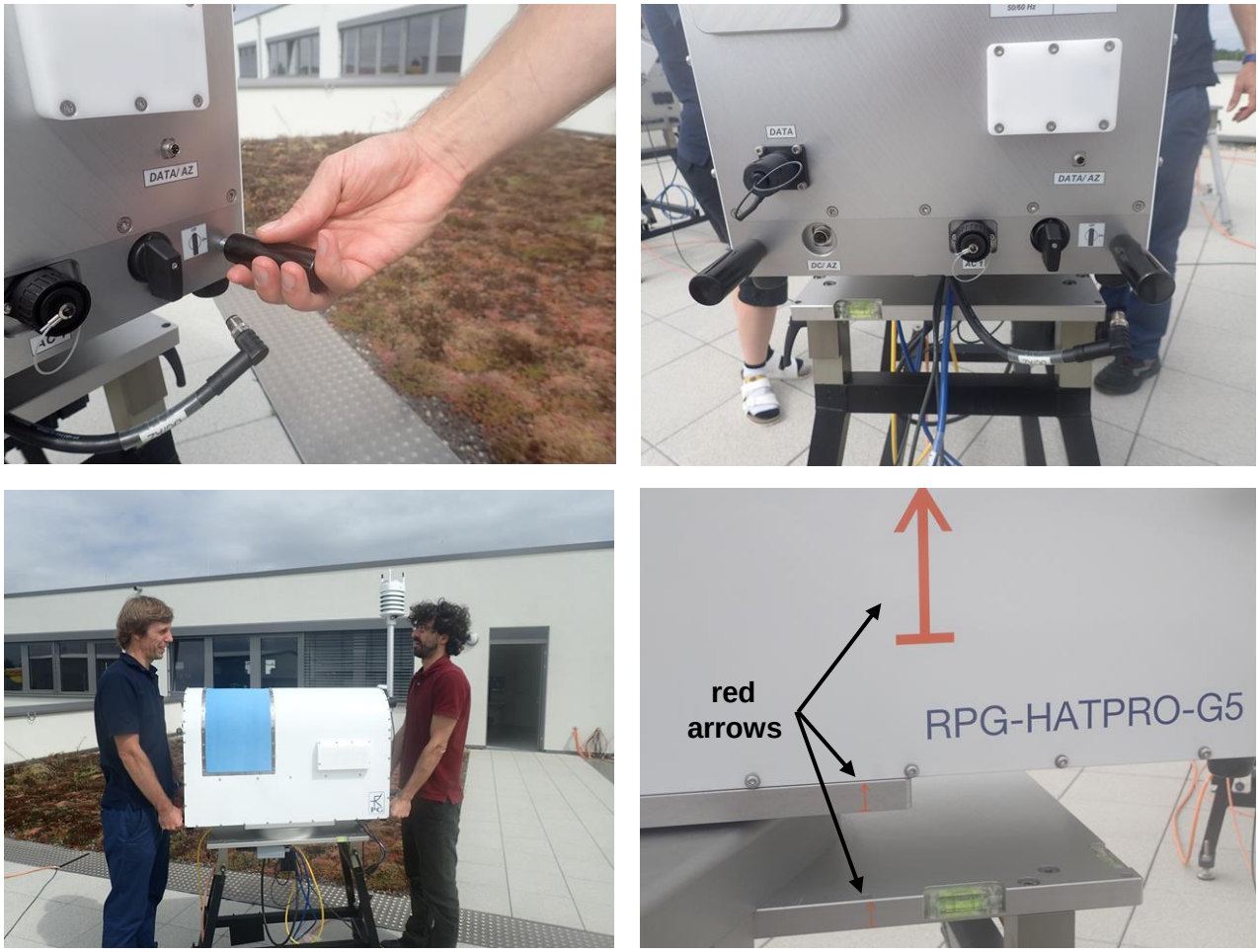


Fig.2.5.2: Use the mountable handles to position the radiometer box on the azimuth driver table. Make sure that all red arrows are on the same side.

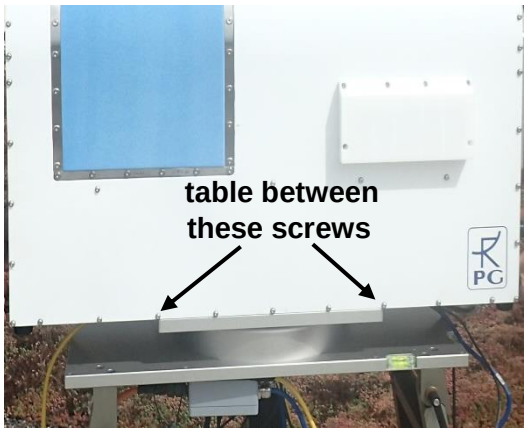


Fig.2.5.3: Four M8x25 screws for fixing the radiometer box to the azimuth driver table.

Fig.2.5.4: Use Allen key to fasten the box with four M8 screws.

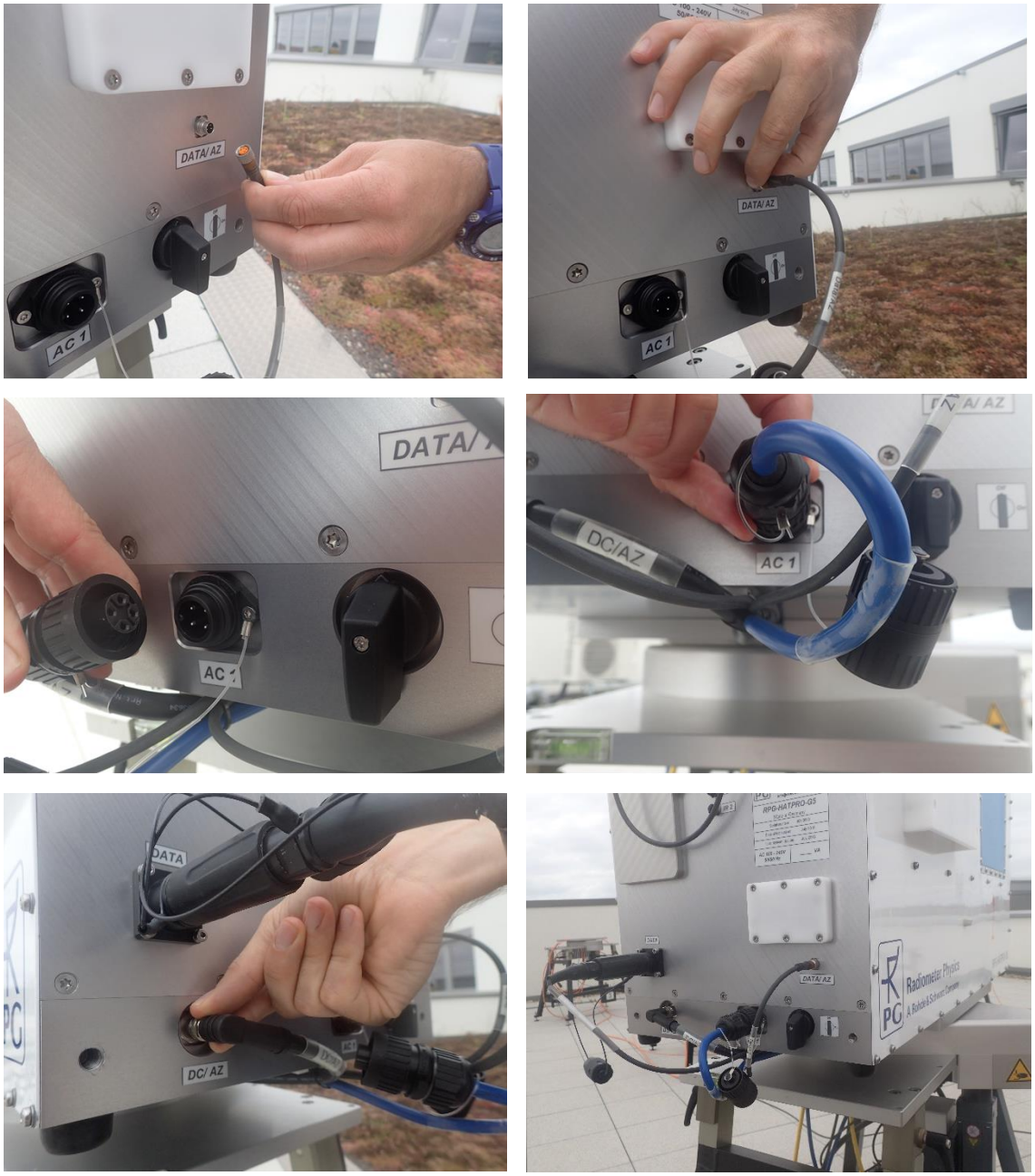


Fig.2.5.5: Connecting the blue AC1 cable, the black azimuth driver interface (DATA/AZ) and the black DC/AZ cable.

The fiber optics connector comprises collimation lenses on both fiber ends which prevent defocusing and connection loss under cold environmental conditions. Both ends are equipped with a pin and a hole which indicate how to be connected (see Fig.2.5.6). Pay attention when unscrewing the cap of the fiber optics cable, do not break it.

Fig.2.5.6: Connecting the fiber optics data cable.

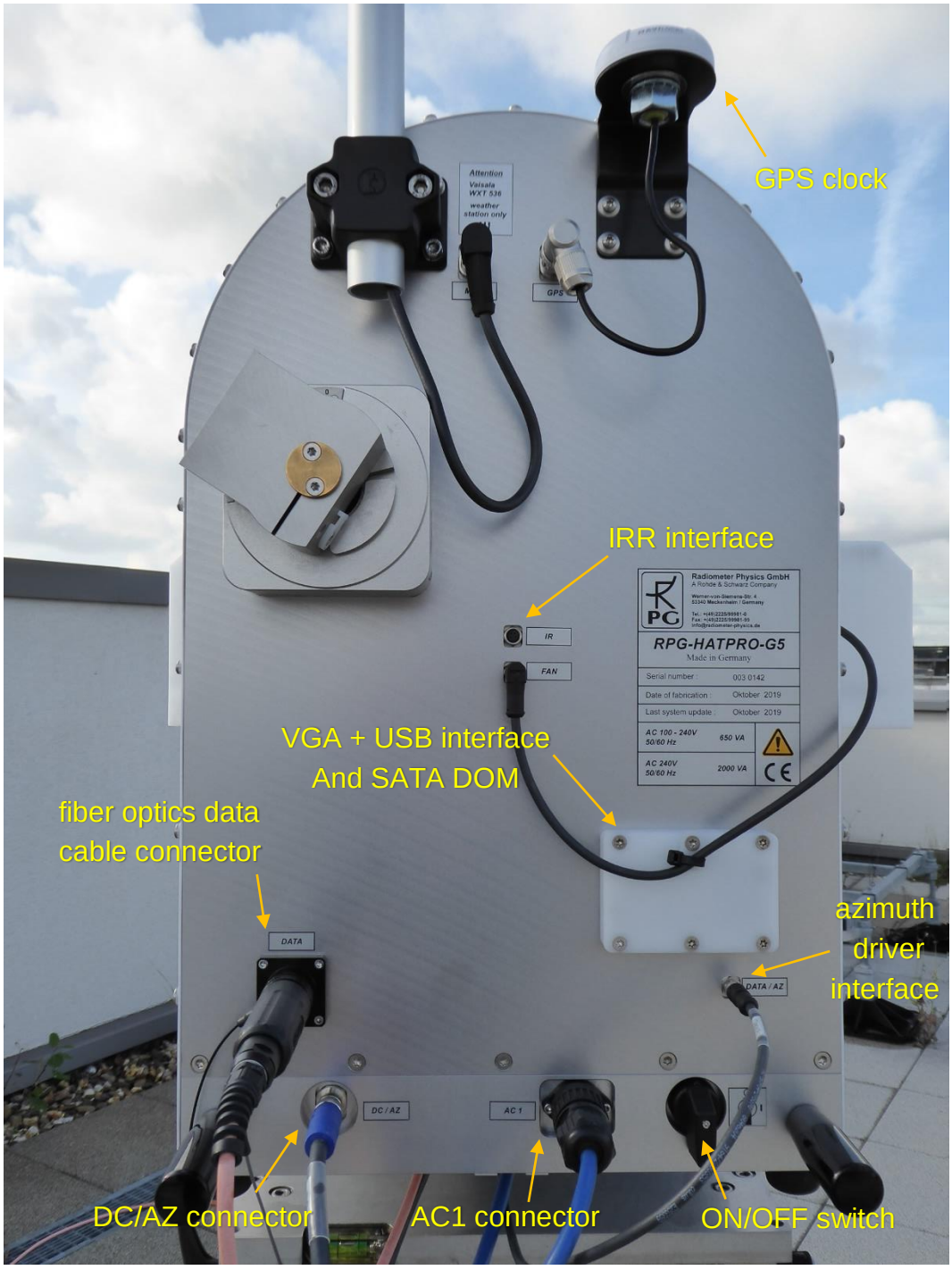


Fig.2.5.7: Connectors on the side wall. The service connectors VGA and USB, and the SATA DOM are accessible removing the plastic protection cap hold by 6 Torx screws.

Fig.2.5.7 shows the different connectors, switches and sensors on one of the two side walls. For transportation, protection caps must be mounted to each connector.

After these connections have been performed (Fig.2.5.7), **the cables should be pulled back to get the right length on the sidewall** (Fig.2.5.8). Finally, they are fixed to the radiometer's bottom plate by one or two cable ties (Fig.2.5.9).

Adjusting the cable length and tie them to the radiometer's bottom plate is necessary to avoid that any cable is caught and ripped off by the azimuth driver movements!

Fig.2.5.8: Pulling back the cables to adjust the cable lengths.

Fig.2.5.9: Fastening cables on the radiometer's bottom plate.

2.6 Mounting of Externals (Blower, Heater, IRR, Weather Station)

2.6.1 Dew Blower

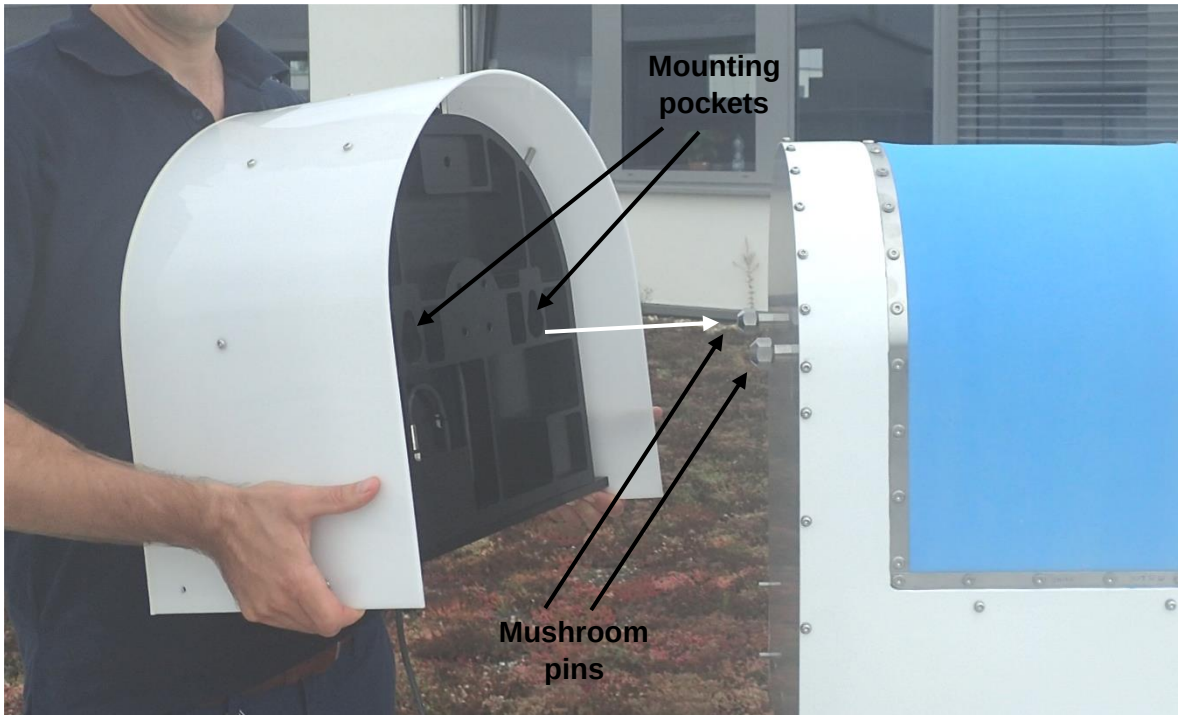


Fig.2.6.1.: Dew blower with mounting pockets.

Fig. 2.6.1. shows the dew blower with its mounting pockets. When attaching the blower to the radiometer, the mushroom pins have to slide into these pockets.

Fig.2.6.2: Sequence of movement.

The first step is to push the blower against the radiometer housing so that the mushroom pins slide into the blower's mounting pockets (1 in Fig.2.6.2). In the second step, the blower is released to slide downwards (2 in Fig.2.6.2), so that the mushroom pins get locked inside the pockets.
In order to remove the blower, the inverse movement is required, e.g. when packing the radiometer back to its box. The blower has to be removed from the radiometer housing in order to unmount the radiometer from the instrument stand. Each time the instrument is packed or unpacked, the blower has to be mounted or dismounted in this way.

2.6.2 Heater Module

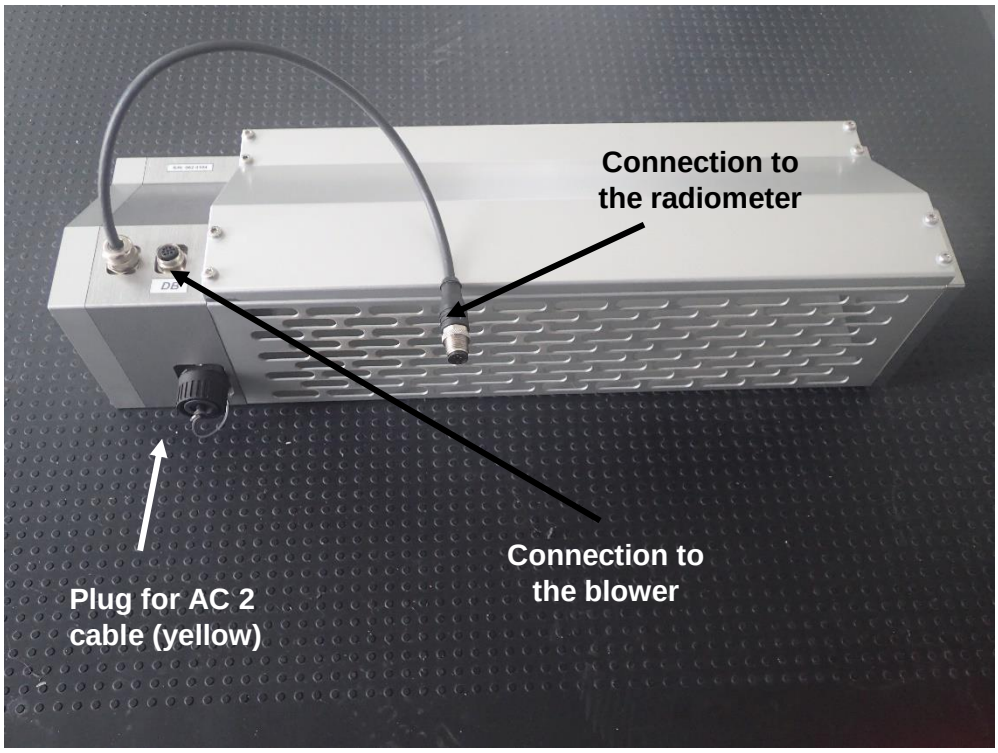


Fig.2.6.3: Dew blower heater module with mounting points.

Fig.2.6.4: Remove heater mounting screws from the blower.

Fig.2.6.5: Shift the heater module underneath the blower's air inlet and fasten the mounting screws as indicated.

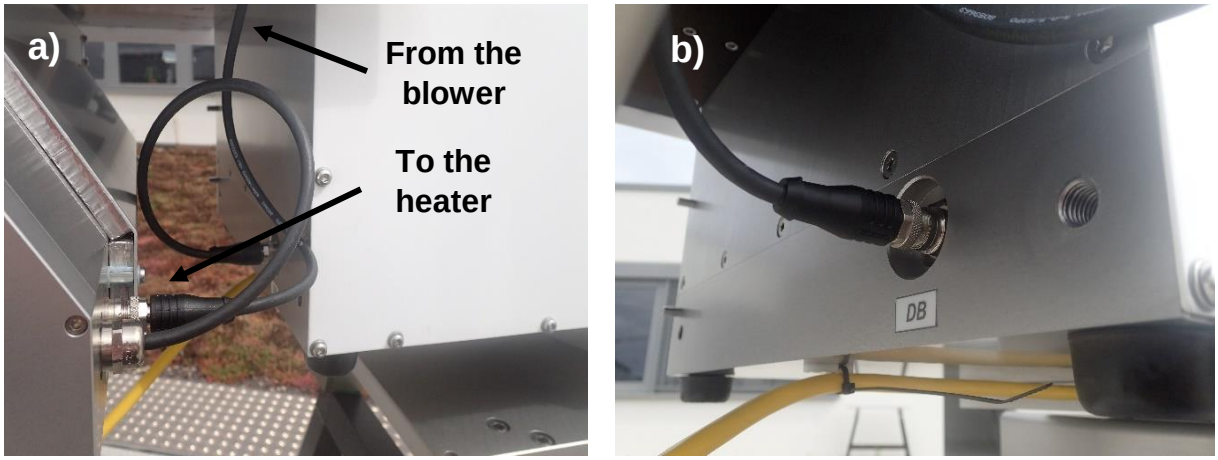


Fig.2.6.6: ConF Fig.2.6.6: First connect blower supply to heater module (a) and then connect heater module to radiometer (b), ('DB' connector socket).

Fig.2.6.7: Connection of AC2 cable (yellow) to the heater module AC input.

Finally, the AC2 cable is fixed at the radiometer bottom plate (Fig.2.6.8) with cable ties.

Fig.2.6.8: Fixing AC2 cable on radiometer bottom plate and cutting the cable tie.

2.6.3 Mounting of IR Radiometer (Optional)

The infrared radiometer data is used as an additional information for retrievals dealing with cloud base height, humidity profiling, LWC profiling, etc. In order to protect the IR optics the system is operated in a tilted position (see Fig. 2.6.10)). The IR beam is reflected by a gold plated mirror to sky directions between 0° (horizontal) and 90° (zenith). This is useful when the IR data shall be combined with microwave observations under elevation angles other than zenith.

Before mounting the IR Radiometer, fix the protective glass tube **gently** to the housing, using 5 torx screws M4 x 20 mm (see Fig. 2.6.9).

Fig.2.6.9: IR Radiometer suitcase. Fix the protective glass tube gently to the housing, using 5 torx screws M4 x 20 mm.

2.6.3.1 Manually Adjustable IRR Elevation Axis

The standard version is a manually adjustable IR radiometer mount (Option IRR-A) as shown in Fig.2.6.10).

Fig.2.6.10: Infrared radiometer mounted to the radiometer side wall on manually adjustable elevation axis. Because of an axial mount the IR radiometer viewing angle can be changed between 0° and 90° and fixed at an arbitrary angle in this range.

Fig.2.6.11: Connecting the IRR to its interface port IR1with a straight cable (a and b) and with a 90° connector cable (c).

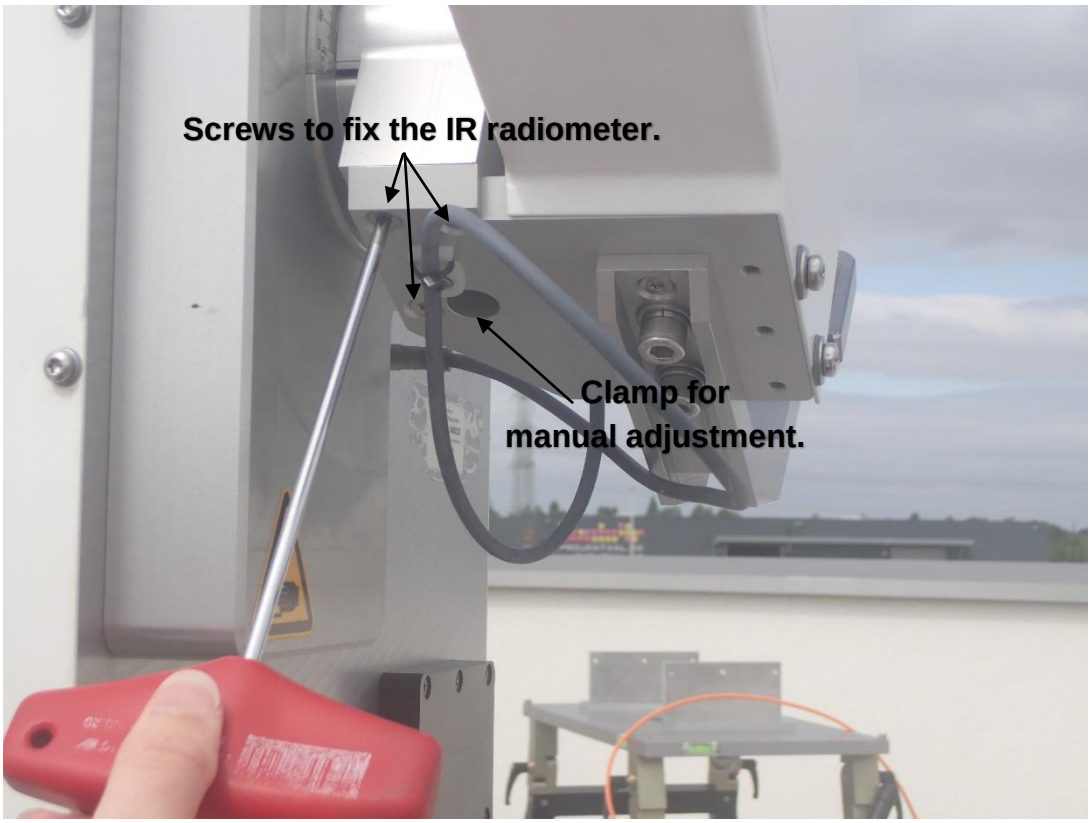


Fig. 2.6.12: Screw the IRR right with three M4 screws. The manual adjustment is then performed by loosening the clamp, rotating the IRR to the desired elevation position (use the elevation scale) and fastening the clamp again.

2.6.3.2 Motorized IRR Elevation Axis (optional)

If arbitrary scan patterns (e.g. volume scans) shall be performed with automatically synchronized elevation pointing of the microwave and IR beams, a motor driven mount is available (Option IRR-B). This option is not a plug-and-play extension and requires a modification of the radiometer housing and electronics. If desired, this feature should be ordered together with the radiometer in order to avoid additional costs in a later upgrade.

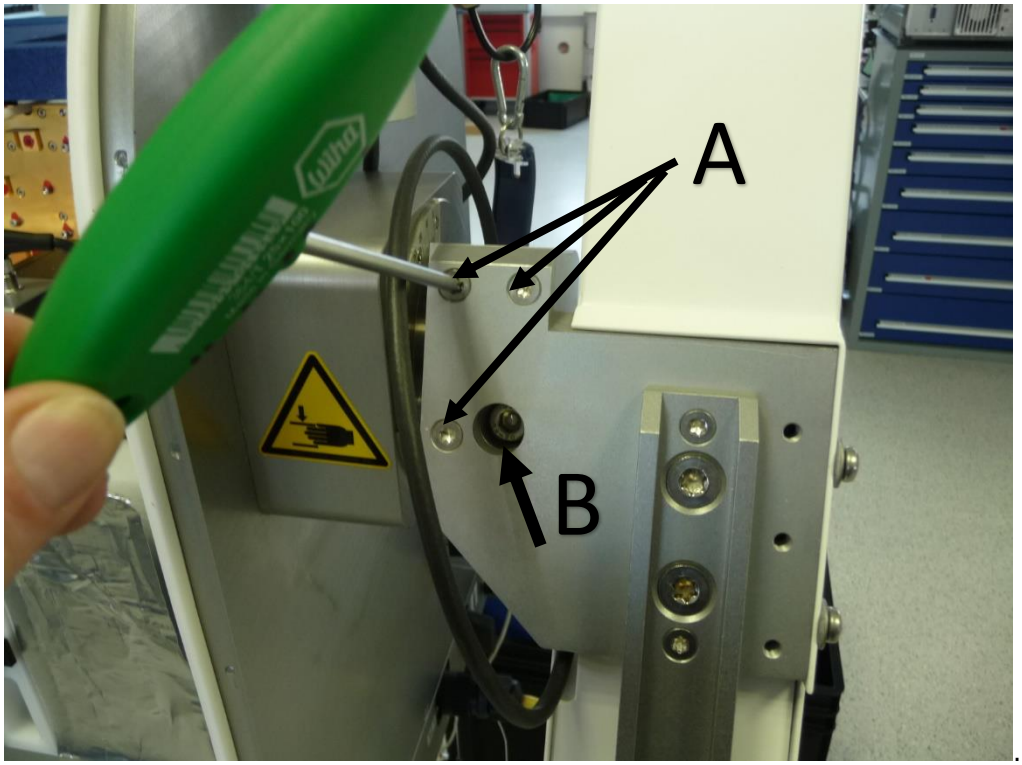
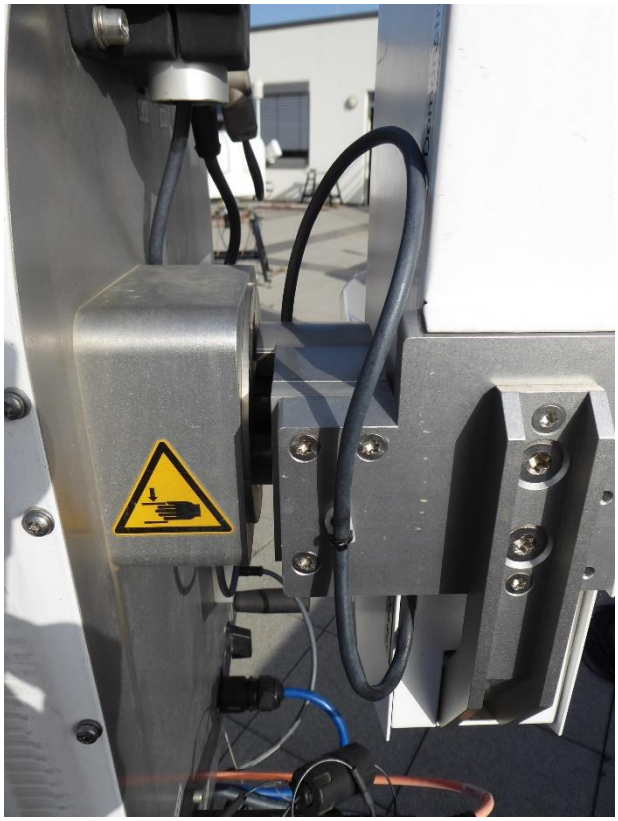


Fig.2.6.13: For the motorized IR-Option (Option IRR-B), the IR radiometer is mounted with three M4 screws (A). NEVER touch the screw in (B). It has been adjusted to an elevation axis tilt accuracy of 0.3°. By loosening (B), this adjustment is lost.

In the case of a **straight IR connector cable**, wire the cable as follows:



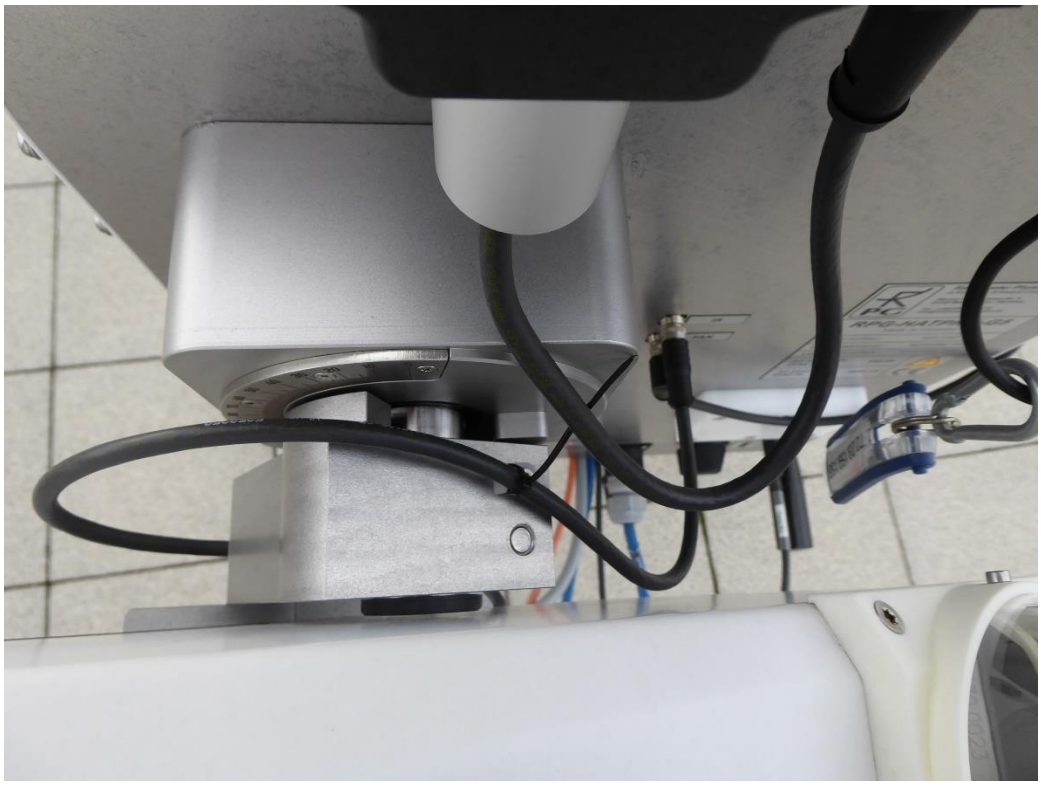
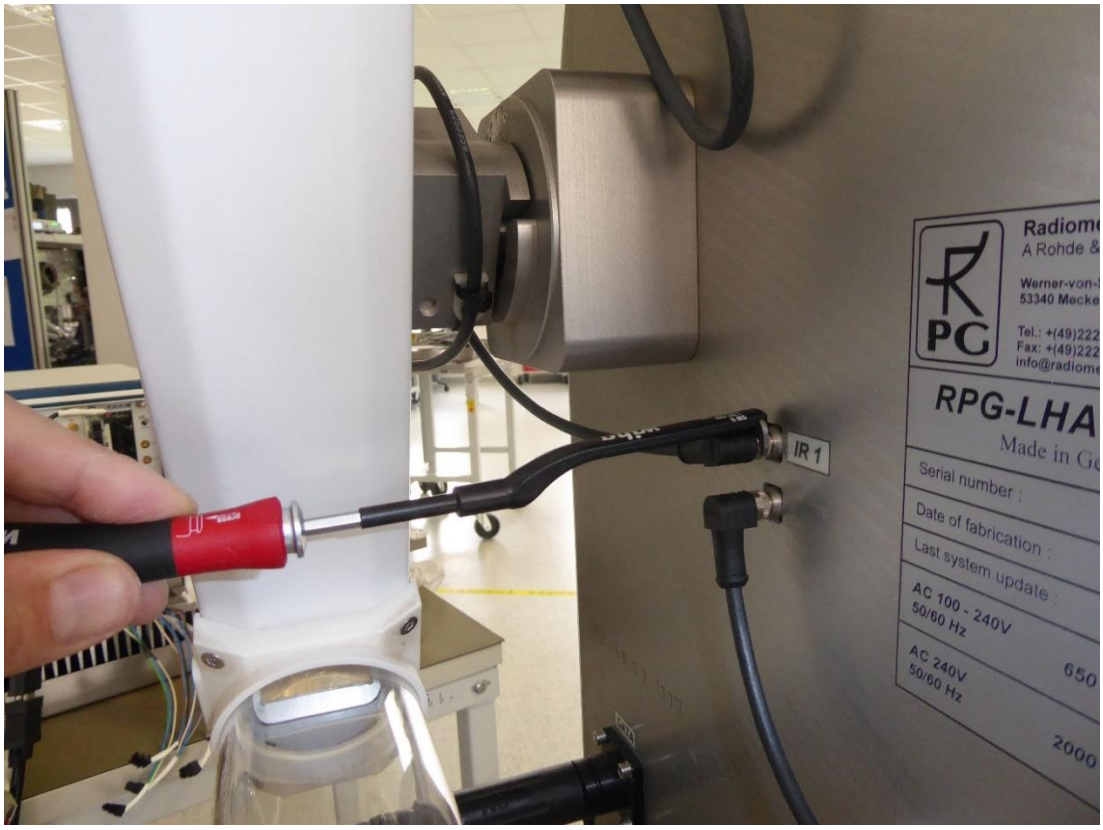


Fig.2.6.14: Motorized IRR cable wiring: straight IR connector cable case.

In the case of a **90° IR connector cable**, wire the cable as follows:



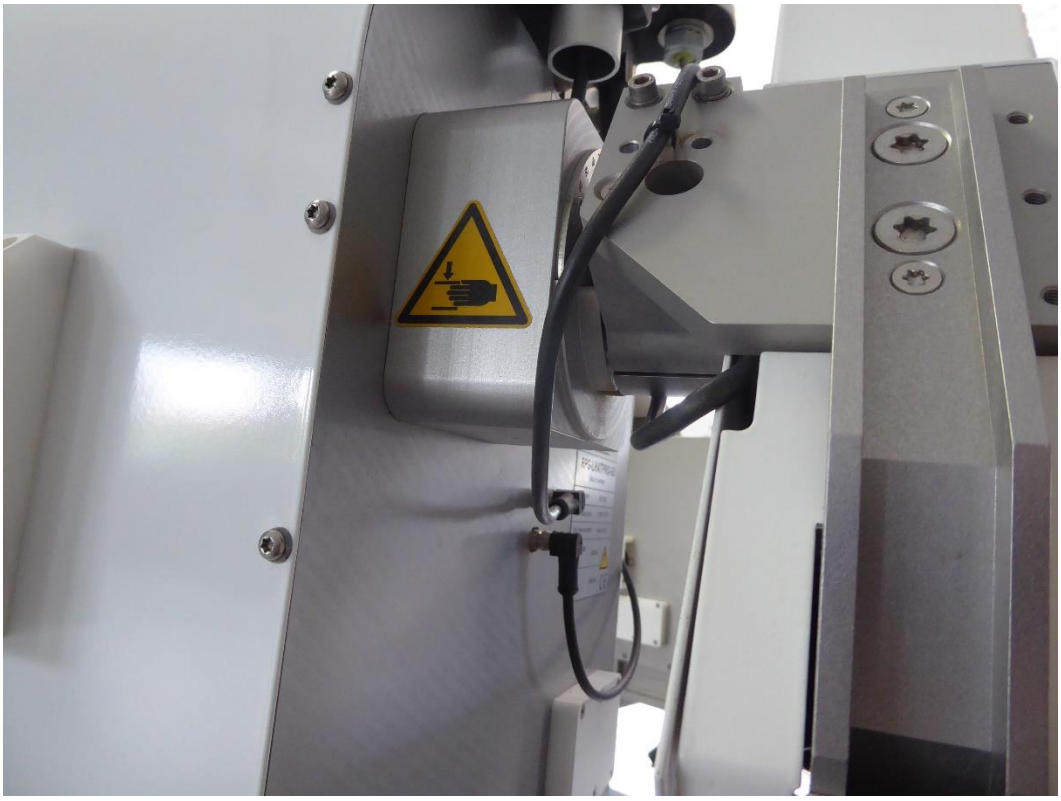


Fig.2.6.15: Motorized IRR cable wiring: 90° IR connector cable case.

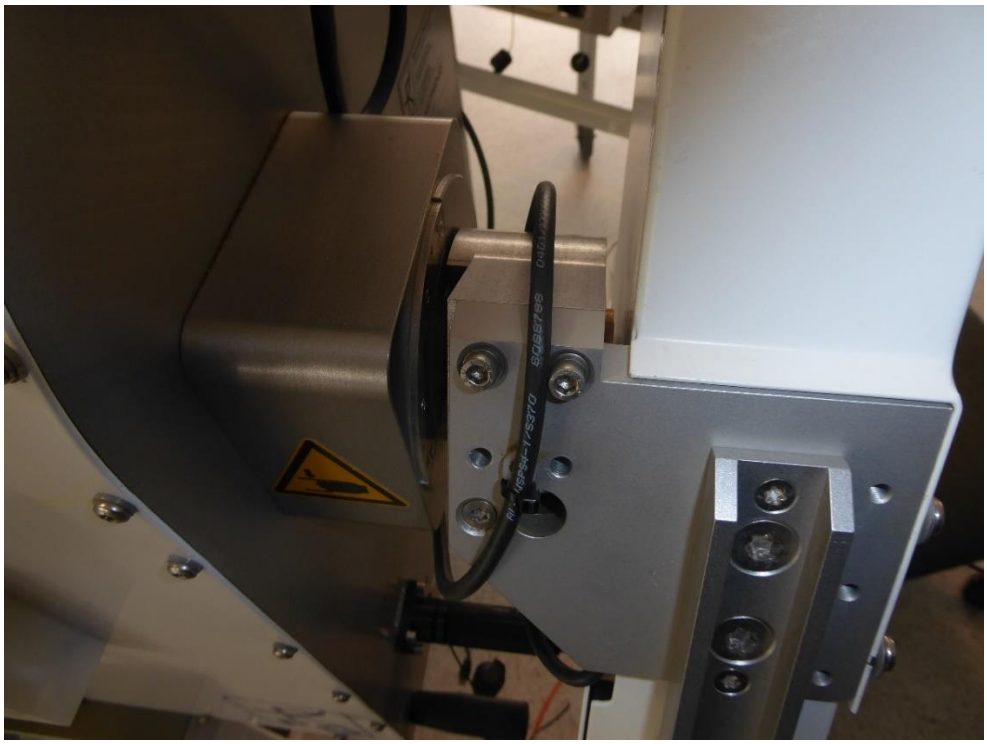


Fig.2.6.16: Motorized IRR cable wiring: 90° IR connector cable case.

2.6.4 GPS Clock

Fig.2.6.17: GPS clock.

The radiometer is delivered with the GPS clock already mounted. The GPS clock shall not be dismounted for transportation.

2.6.5 External Weather Station

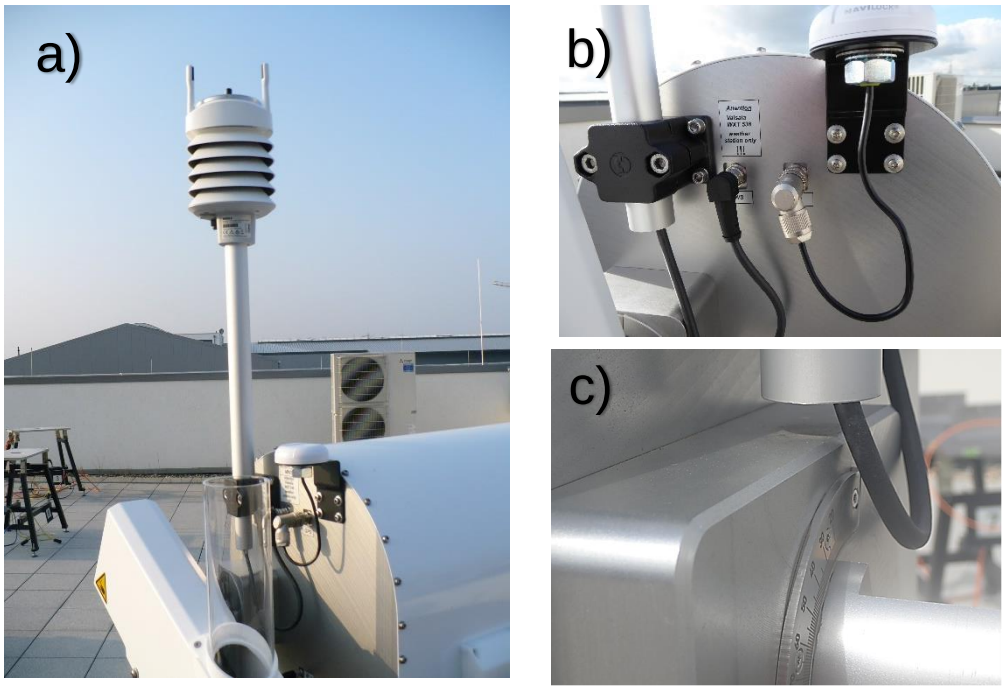


Fig. 2.6.18: a) External weather station Vaisala WXT, b) clamp for fixing and connector socket, c) leave enough space for the cable when mounting the pole.

The external weather station Vaisala WXT is mounted to a 1.2 m long pole which is clamped to the radiometer housing by a black clamp block (Fig. 2.6.18 b). Leave enough space for the cable when mounting the pole (Fig. 2.6.18 c). The Vaisala WXT electrical connector socket is right to the clamp (Fig. 2.6.18 b).

Rotate the steel pole until the N mark (North) on the Vaisala WXT is pointing toward North (Fig. 2.6.19). Then tighten the clamp. If an azimuth drive is installed and the radiometer rotates around the azimuth axis, the wind direction is automatically corrected for the radiometer azimuth.

Fig.2.6.19: Orientation of north mark "N" of the Vaisala weather station.

2.7 Fiber Optic Converter

The one end of the fiber optics system is described in section 2.5 (see also Fig. 2.5.7). The other end of the fiber cable is connected to a Fiber-to-LAN-TCP/IP converter as indicated in Fig.2.7.1. Each of the two line ends has a nose (see Fig. 2.7.2) which has to fit into the fiber socket. After the connector is sliding into the socket (the nose guided by the slit), the bayonet coupling has to be pushed against a spring inside the coupling and then turned clockwise.

Fig. 2.7.1: Fiber-to-LAN-TCP/IP converter.

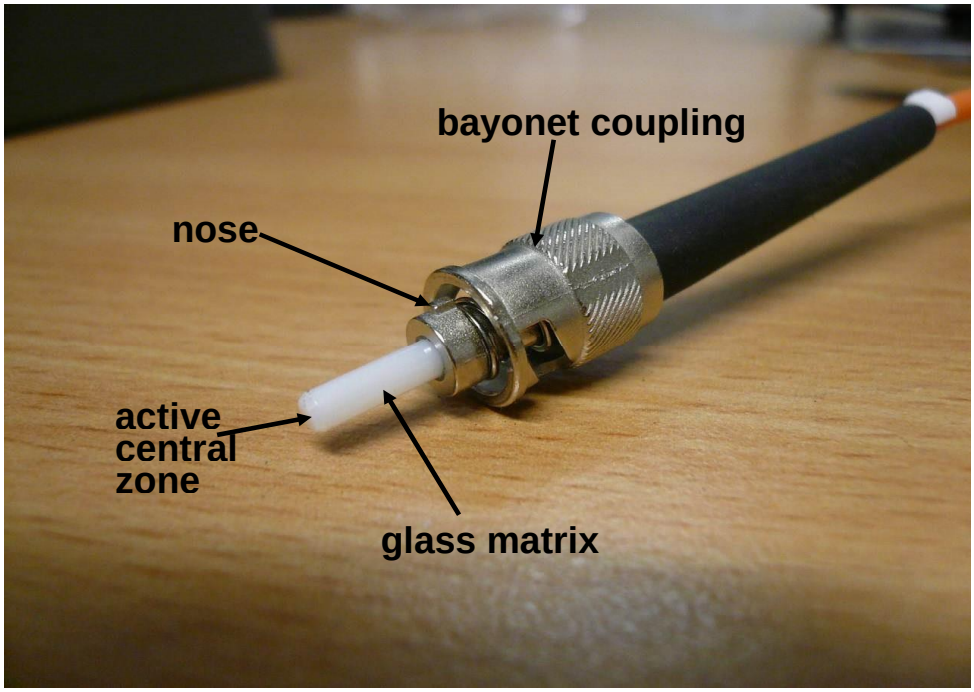


Fig.2.7.2: Details of the glass fiber connector.

The converter has an external power cable. When power cable and the two fiber lines are connected the power LED and FX LED are turned on (see Fig. 2.7.3a). Make sure that the TX fiber line (red or orange) gets connected to the TX converter output and the RX fiber line (blue or black) to the RX

converter input. Via LAN-TCP/IP connection the converter can be connected either directly to the Host PC or to a network. If the LAN cable is connected (see Fig. 2.7.3b) the power and FX LEDs are on and the 100M and TP LEDs are flashing.

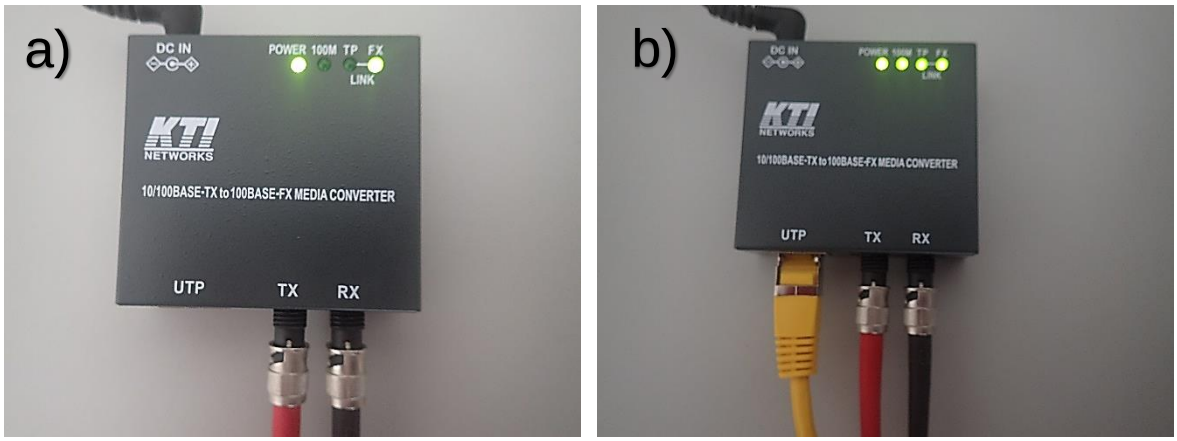


Fig.2.7.3: 2 line fiber optics to LAN-TCP/IP converter.

2.8. Electrical Connections

The radiometer power cable is split into AC1 (supply for radiometer, blue) and AC2 (supply for blower heater module, yellow). AC1 can be buffered via a UPS system (see Fig.2.8.2) in the range 100-240 A/AC, 50-60 Hz. AC2 must be connected directly to a power outlet at 220 V/AC or via a 110-to-220 V transformer to a 110 V/AC power outlet. The heater will not be damaged if it is connected to a 110 V/AC line, but the heater power is reduced from its standard 1800 Watts down to 450 Watts in this case. 450 Watts of heater power is not efficient enough for drying the microwave window. For 110 V/AC outlets, it is therefore recommended to use a transformer to produce 220 V/AC to power the heater.

The fiber optics data cable is more sensitive to mechanical stress than a usual copper cable and, in case of damage, it needs to be repaired by a specialist. Certain treatments of the fiber optics cable should be avoided in order to maintain the functionality of the cable (see Fig. 2.8.1), like pulling the cable with strong force or like stepping on it.

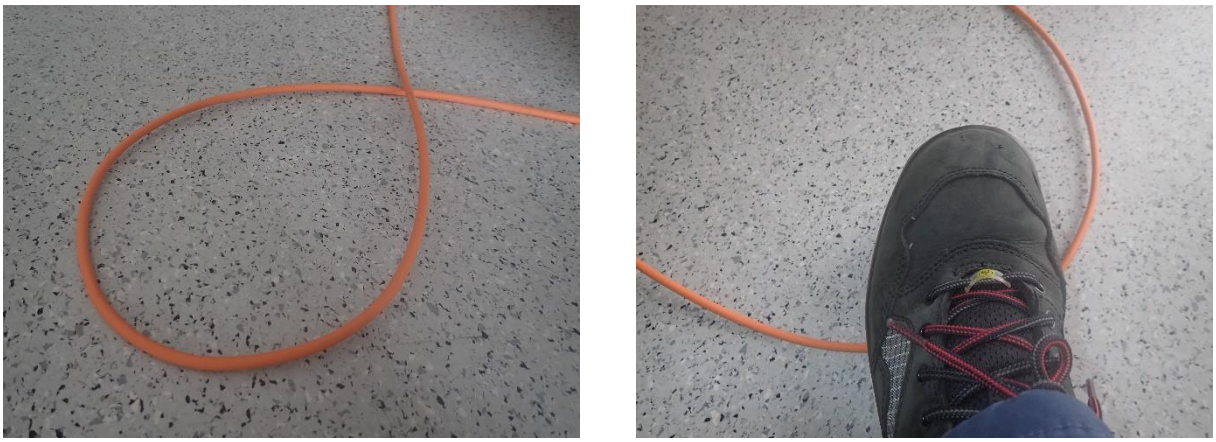
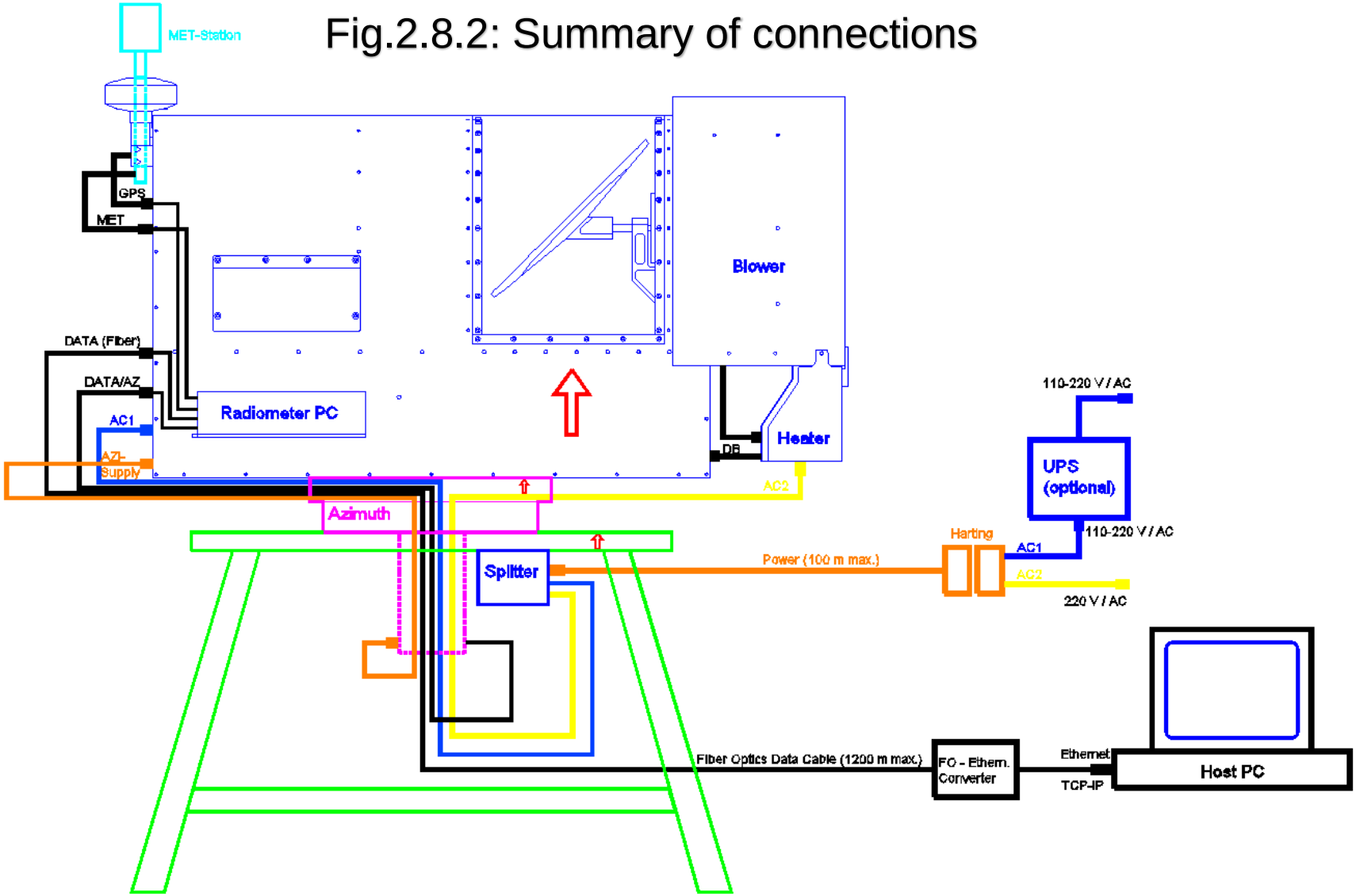
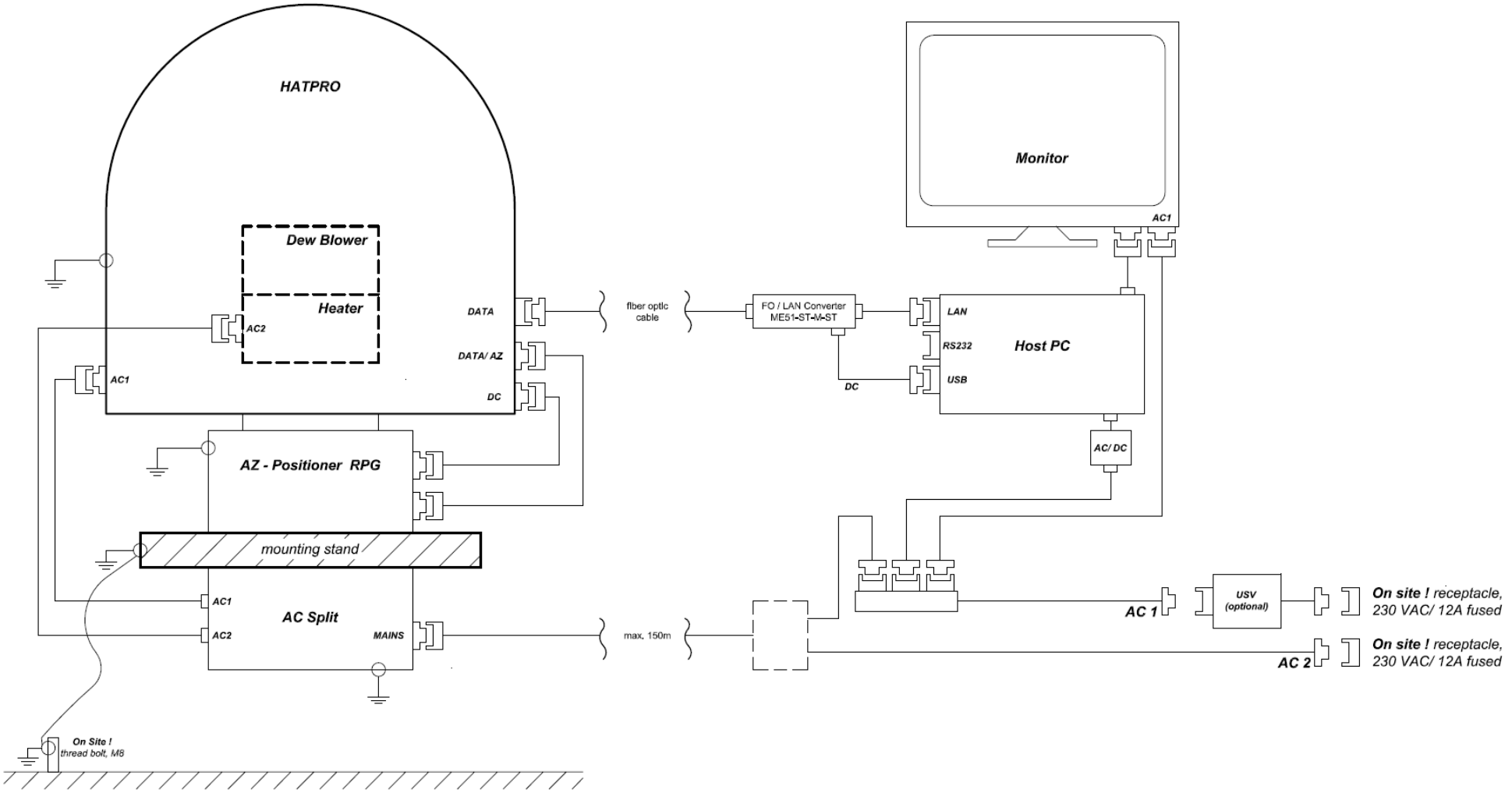


Fig.2.8.1: Avoid loops in the fiber optics cable. The curvature radius should not be less than 5 cm. Crossings of cables can lead to cable damage when stepping on it.

Fig.2.8.2: Summary of connections




HATPRO
Dew Blower
Heater
AC2
AC1
DATA
DATA/ AZ
DC
AZ - Positioner RPG
mounting stand
AC1
AC2
AC Split
MAINS
On Site !
thread bolt, M8
fiber optic cable
max. 150m
FO / LAN Converter
ME51-ST-M-ST
DC
Monitor
AC1
LAN
RS232
USB
Host PC
AC/ DC
AC 1
USV
(optional)
On site ! receptacle,
230 VAC/ 12A fused
AC 2
On site ! receptacle,
230 VAC/ 12A fused

2.9 Recommendations for Viewing Directions and Angles

Fig.2.9.1 and 2.9.2 show the requirements for the free viewing ranges. When sky-dip (tip curve) calibration is enabled, the radiometer performs an elevation scan from zenith to 20° elevation. No obstacles should be in that viewing range to ensure a good calibration.

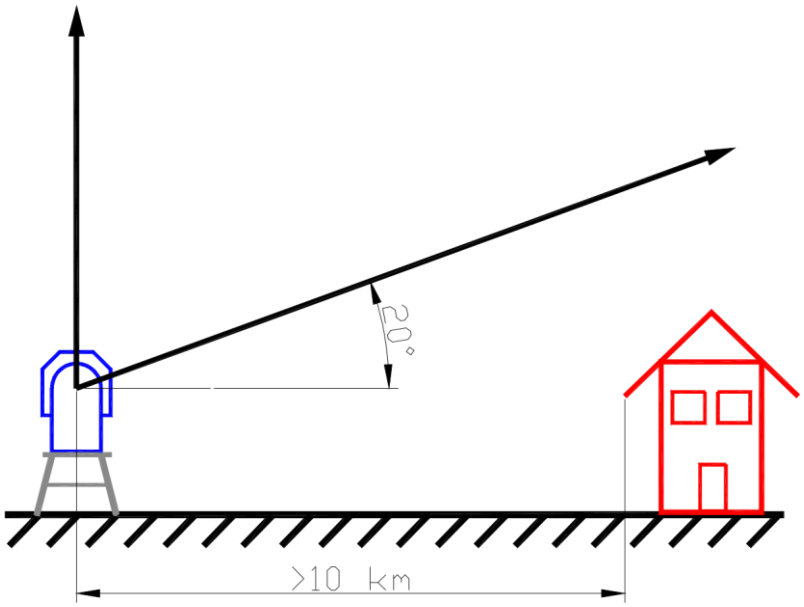


Fig.2.9.1: Tip curve calibration viewing range.

For boundary layer temperature profiling the instrument performs an elevation scan between zenith and 5° elevation angle. No obstacles should block the beam within a distance of 1 km.

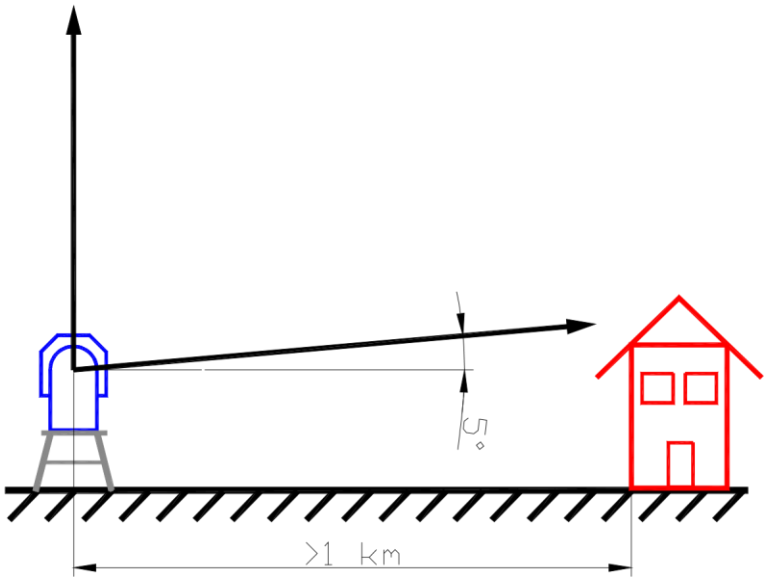


Fig.2.9.2: Boundary layer scan viewing range.

3 Quick Start Guide

3.1 Power up

After installation according to the safety instructions and guidelines illustrated in section 2, the instrument is ready to be turned ON. The main switch is located in the lower right corner of the radiometer's side wall:

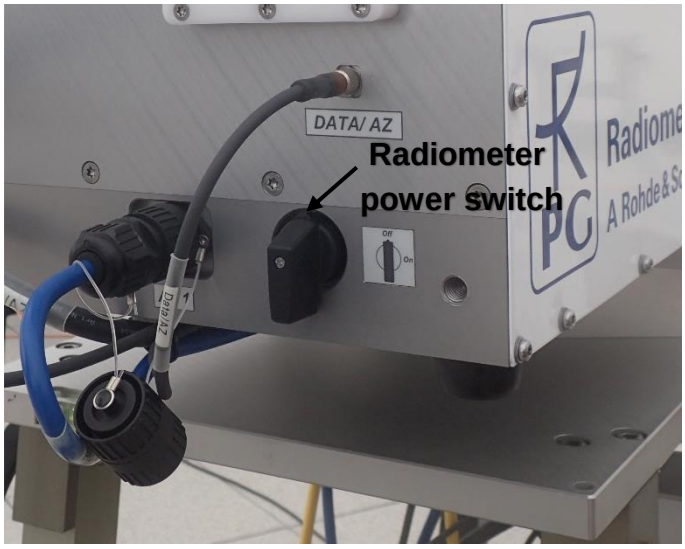


Fig 3.1.1: Radiometer power switch in OFF position.

After turning the switch to the ON-position, the radiometer initializes all interfaces. If an azimuth positioner is installed, the table will turn to its zero index position. Also the microwave mirror inside the radiometer box is adjusted. The motor movement can usually be heard when standing close to the radiometer. The blower, which runs on two speeds, will shortly be switched to full power mode during the initialization phase.

To avoid water condensation, the radiometer **must be switched on** at all times when deployed outdoor and thus in temperature stabilized conditions. The hardware is designed to be operated for years without interruption.

3.2 Connect Host to Radiometer

The radiometer will be controlled using the RPG control software R2CH. Copy the whole folder named RPG-HATPRO containing the R2CH executable from the USB flash drive provided with the instrument to the host PC. Take care to start the R2CH software as **administrator**.

When clicking the desktop icon the application is started. Click  to set the radiometer's IP address of the radiometer:

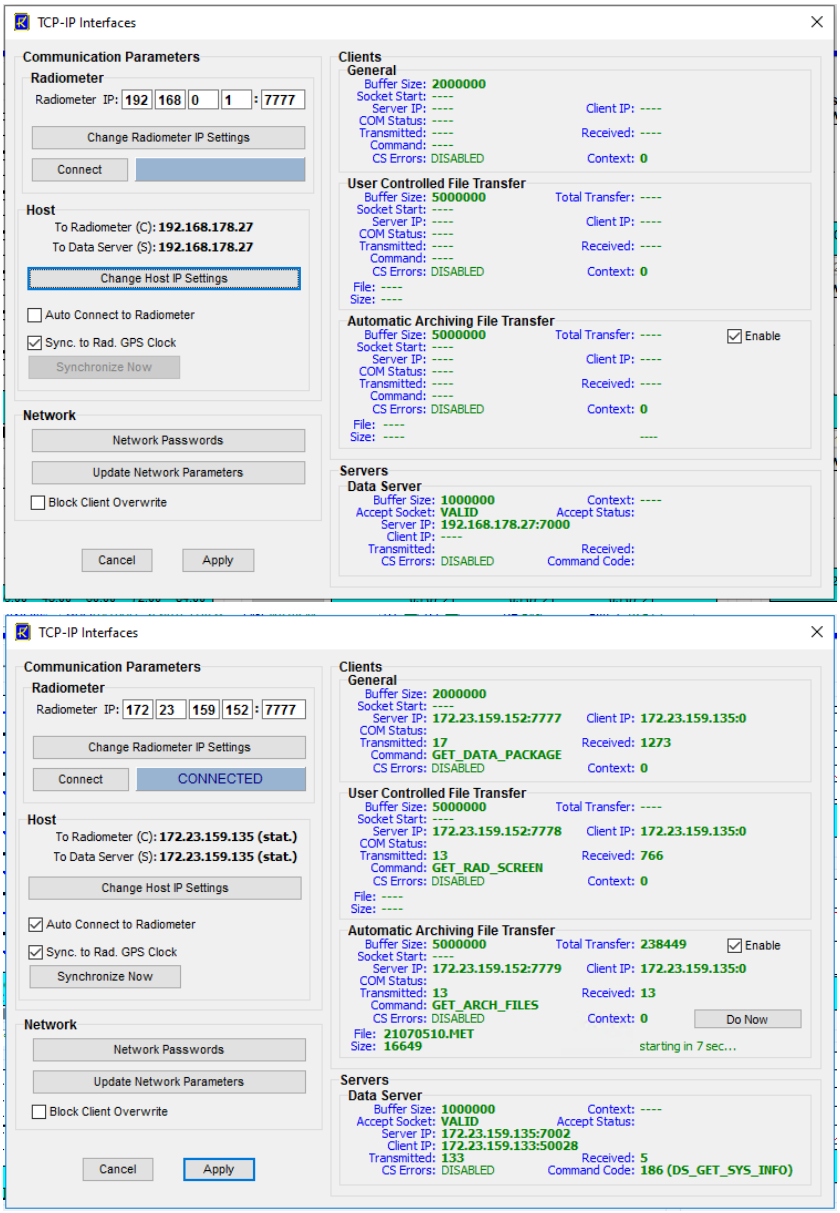


Fig.3.2.1: Ethernet interface menu.

The R-PC is delivered with a certain fixed IP address (**default: 192.168.0.1, port no.:7777**) which can be altered later. For a fist connection, the user needs to enter this IP to the edit fields right to 'Radiometer IP'.
When a connection with the radiometer has been established, its IP and gateway can be changed, e.g. when the radiometer shall be connected to a network, click ***Change Radiometer Settings*** (a new menu pops up) and edit the fields to the desired numbers:

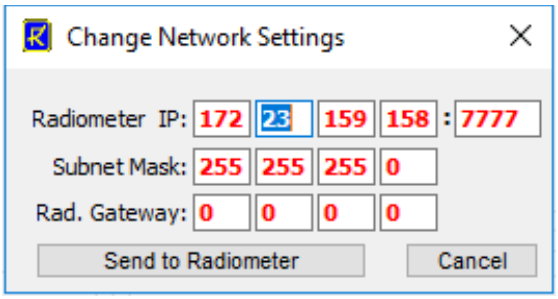


Fig.3.2.2: Change Network Settings.

The radiometer does not have anti malware programs installed. Please make sure to protect the radiometer when connected to a network with internet access.

The red IP / gateway settings are sent to the radiometer by clicking ***Send to Radiometer***. After new IPs have been successfully sent to the R-PC, it will be no longer reachable through the old IP / gateway addresses. In the case of a successful transfer of the new IP / gateway to the radiometer, the new IP is copied to the current IP fields automatically so that the H-PC can continue its connection to the radiometer. Then click ***Connect***. The H-PC will then try to get access to the R-PC via the specified IP address. If the connection is successful, 'CONNECTED' will show in the blue field, otherwise 'No Connection'.

3.3 Sending a Measurement Definition File

The details of how to define a measurement definition file (MDF) are not explained in this manual. Please refer to the software manual for more information about MDFs.

In the following, we assume that a valid MDF file is already defined and stored to a directory on the Host PC. Click the 

button (***Send Measurement Configuration*****).**

Drag and drop one of the displayed MDFs to the radiometer image on the right. The measurement will automatically start.

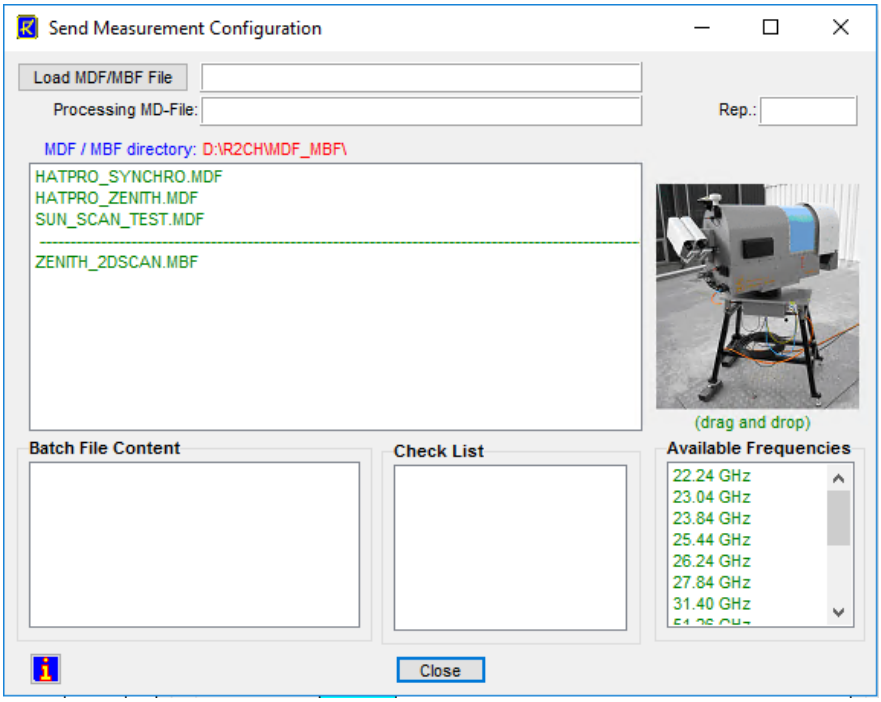


Fig.3.3.1: ***Menu for sending an MDF or MBF to the radiometer.***

3.4 Browsing Through the Measurement Displays

In order to inspect the measurement data, click one of the tags ***Status and Conf.***, ***BTs***, ***24 Hour History***, ***TimeSeries***, ***Profiles***, ***SkewT + Stability***, ***2D-Maps***, ***Attenuation***, ***Sat. Tracking*** or ***Housekeeping***.

***Status and Configuration*:** This group includes the status display of the radiometer and measurement information like the current processed MDF, current data filename, activation status of file backup, start and end time, etc.

Brightness Temperatures: All brightness temperatures, at both microwave and IR frequencies, are displayed in this group.

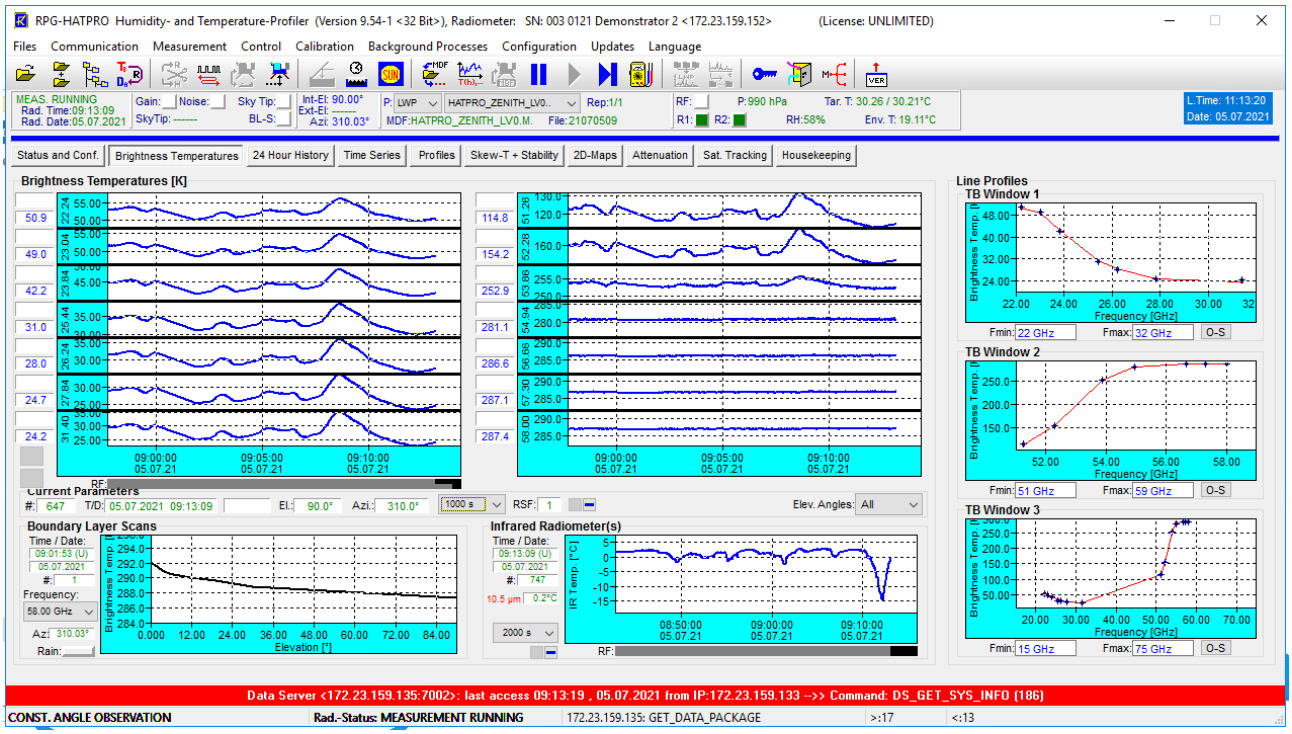


Fig.3.4.1: ***Brightness temperature information.***

The display includes the time series of each available microwave and IR channel, the boundary layer scan information and the line profiles, if applicable (e.g. the water vapor and oxygen lines). The three **TB Windows 1-3** each show a subset of the microwave channels that is defined by entering the Low Limit and High Limit of the displayed frequency range.

Time series graphs can be changed by selecting a different time axis period from the time axis selection box.

Atmospheric Data (24 hours): A 24 hour history of IWV, LWP, meteorological sensors and profiles is continuously updated in this group. The IWV, LWP and sensor data displays can be individually changed to a 3, 6, 12 or 24 hour history. In the profiles boxes, color scales, vertical axis limits and contour values may be changes for the data monitoring. The humidity profile window has a selection button for displaying absolute or relative humidity.

Atmospheric Data (Time Series): This group includes time series of liquid water path (LWP), integrated water vapor (IWV), cloud base height (CBH) information and the surface sensors (temperature, rel. humidity and barometric pressure). CBH data is available for all temperature profiling radiometer models (RPG-HATPRO, RPG-TEMPRO, RPG-TEMP90) if the IRR option is installed. LWP, IWV and CBH are retrieved data products and are therefore quality checked. The quality level (High, Medium, Low) and the possible reason for reduced data quality is shown below the time series charts. All time series include a rain flag display. Each window displays the current reference time, date, sample number, sample value, retrieval type (if applicable) and cursor position (when the mouse cursor is moved into the display area).

Current Trop. Profiles: The group summarizes all available profiles. There are three temperature profile displays, one for the boundary layer scan (TPB) with high vertical resolution (range 0-2000 m), one for the zenith observation (TPC, full troposphere profile with coarser resolution in the boundary layer) and one for the composite profile (CMP.TPC). The composite temperature profile is a combination of the high vertical resolution boundary profile and the full troposphere profiles.

Both profiles are linked together at the 1200 m altitude level by applying a cubic spline fit. The temperature profiles are in blue color while the dew point temperature profiles are in green. Dew point information is only available (and displayed), if the radiometer is equipped with a humidity profiler. Absolute humidity and dew point temperature are only different versions of the same information content. Like with all temperature displays, the temperature axis can be scaled to Celsius, Fahrenheit or Kelvin.

On the bottom of the screen the diagrams for absolute humidity (HPC), relative humidity and the liquid water profile (LPR) are shown. The LPR data product is automatically generated when the products LWP, IWV and IRT are selected in the MDF product list and a retrieval for the maximum LWC is installed in the LWP retrieval directory (must have the same retrieval filename as the LWP retrieval but starting with ‘LWM’ instead of ‘LWP’). X-axis: LW-density [g/m^3], Y-axis: altitude [m].

Skew-T & Stability: This group includes a skew-T and a stability index display. Six of the most common stability indices (lifted index, K-index, KO-index, Showalter index, CAPE index, total totals index) are monitored. X-axis: measurement time, Y-axis 1: [K] index, Y-axis 2: CAPE index [J/m^3]. By double clicking on any of the stability indices boxes more information about the chosen index will be provided.

The skew-T plot is automatically generated when temperature and humidity profiles are sampled. Also the stability indices are computed and stored in files of extension ‘.STA’. The displayed temperature and dew-point profiles can be analyzed graphically by using the cursor on the skew-T chart. The cursor coordinates, P and T, are monitored as the cursor is moved across the diagram. Other useful information like the LCL (Lifted Condensation Level) and LFC (Level of Free Convection) is marked on the Skew-T.

Attenuation: This display is similar to the brightness temperature diagram and monitors the time series of atmospheric attenuation. The vertical axis unit is dB as the standard unit for damping parameters. The attenuation is only calculated for the microwave channels, not the IR ones. The standard attenuation retrievals are applicable for all elevation angles and can be used in scanning mode.

Satellite Tracking: If satellite tracking is enabled in the running MDF, the scanned satellite information, like satellite number, navigation file, satellite elevation and azimuth position, wet path delay and LWP along line of sight and atmospheric attenuation are listed for each scan.

Housekeeping: Data like GPS position, receiver stability, system temperatures (ambient target, receiver temperatures), flash memory capacity, quality flags and system status flags are monitored. By clicking the ***Legend*** button, the color codes for the different flags are listed. An ALARM indicator warns the user if a systematic problem with the radiometer has occurred. A detailed description of housekeeping flags is given in appendix A18 of the software manual.

3.5 Starting/Stopping Measurements

 (***Halt Running Batch***)
A running measurement can be halted any time. This might be useful when e.g. the user wants to change the elevation angle manually. The status bar display changes to “MEASUREMENT HALTED”.

 (***Continue Interrupted Batch***)
Used to continue a halted measurement. The status bar display changes back to “MEASUREMENT RUNNING” and the manual control button is disabled.

 (***Terminate Running Batch***)
This command terminates the execution of the currently running batch. The radiometer switches to STANDBY mode and is ready to receive a new MBF or MDF.

4 Maintenance

4.1 Cleaning

RPG radiometers are designed to withstand all kind of weather and climate conditions. However, it is a good practice to prevent accumulations of dust, dirt, debris, salt (if located close to the sea), and other pollutants on the weather station, on the dew blower, on the radiometer housing, and on the microwave window. Such cleaning is best done

- With pure fresh water (no chemical detergents, soap, solvent etc.)
- Without applying mechanical force, especially to the microwave window
- Just by watering and spraying gently to wash away the accumulated pollutants (and thus simulating a rain shower…)

The air inlets to the radiometer (cooler slits at sidewalls of main housing) and the inlet of the dew blower/heater device need to stay clear from large scale size debris (leaves, spiderweb, insects, etc.).

In areas with extreme snow amounts and ice-rain, the radiometer needs to be checked for snow/ice obstacles which would prevent the moveable parts (if any, depending on the selected options) from rotating. This affects the azimuth positioner and the IR elevation scanner.

All these cleaning activities need to be carried out according to the demand generated by the specific local environmental conditions. The intervals vary from twice a year (during the recommended LN2 calibrations) to weekly or daily (on ships). See section 4.5 Preventive maintenance) for the frequency of maintenance in standard conditions.

4.2 Software Upgrades

1. Step: Save the old software versions

a) Create a directory to save the old software versions (e.g. C:\MyPath\SAVE).

b) Connect the host to the radiometer and enter the File Transfer Menu ( , Fig.4.2.1). On the left side (Host) browse to the directory for saving the files (e.g. C:\MyPath\SAVE) and on the right side (Radiometer) in the RPG-Radiometer Directory mark the RadPC.EXE file. Then drag and drop the RadPC.EXE file to the C:\MyPath\SAVE directory to initiate the copy process.

c) Locate the R2CH.EXE file in the MyPath\RPG-HATPRO directory and copy this file to the C:\MyPath\SAVE directory (by using the Operating System Explorer).

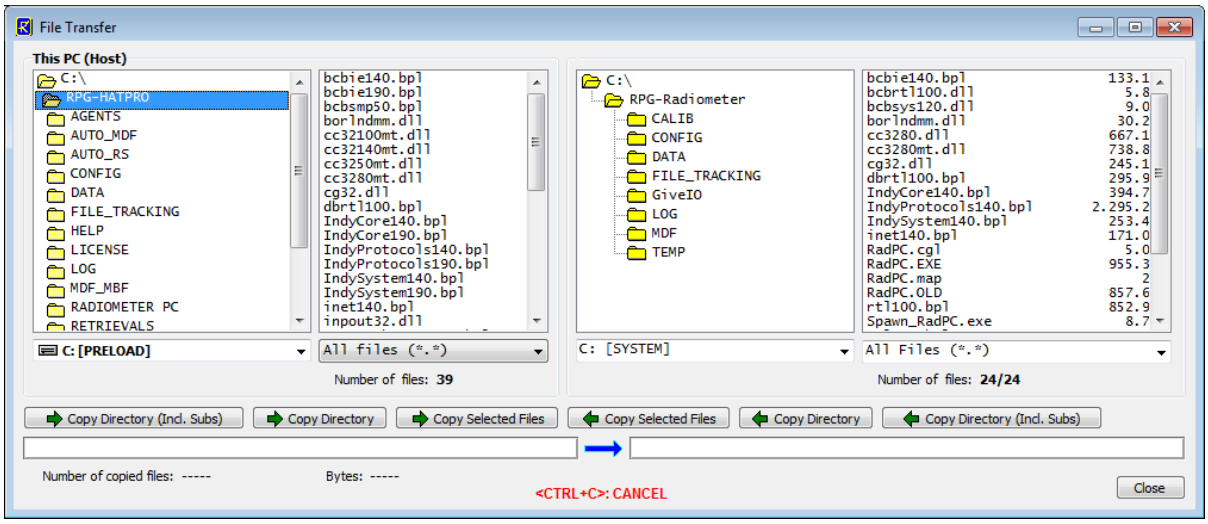


Fig.4.2.1: File Transfer Menu

2. Step: Overwrite the old versions by the new ones

a) Enter the Software Update Manager (

, Fig 4.2.2).
b) Use the browse buttons to select the radiometer and host-PC software executables.
c) (Optional) If instructed by the RPG support team, browse and select also the “Accessory SW”.
d) Tick the “Update” tick boxes in correspondence to the software to be updated (only radiometer, only host-PC, or both).
e) Start the update process

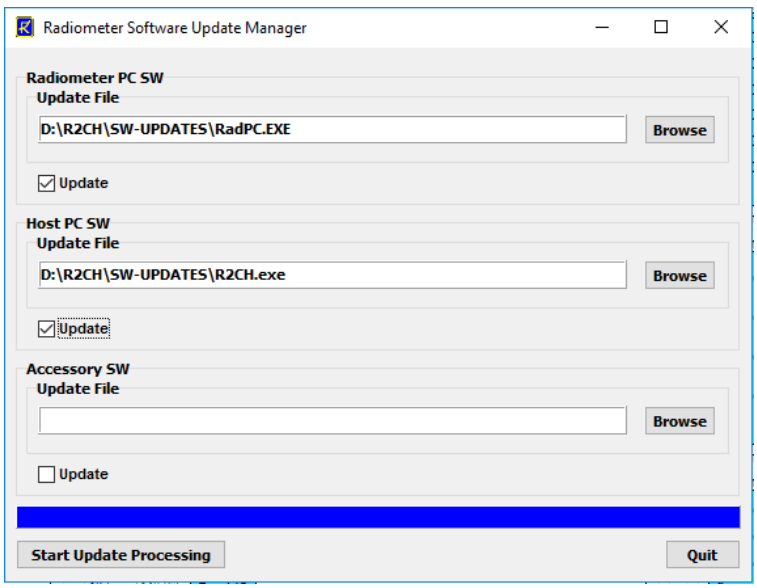


Fig.4.2.2: Software Update Manager window

The software upgrade is finished. You can confirm the successful upgrade by reading the software version numbers of both, the embedded radiometer PC (see main window radiometer status display) and the host PC (see main window caption).

4.3 Absolute Calibration Procedure

It is assumed that the radiometer has been setup properly:

- The instrument is aligned horizontally.
- A connection between the Host-PC and the internal Radiometer-PC has been established.
- The instrument completed the warm-up phase, i.e. radiometric receivers are stabilized (green stability flags).

As a final step towards regular operations the user has to perform the absolute calibration procedure. The absolute calibration relates the observed detector voltages U_{det} to measured brightness temperatures of the scene (T_{SC}). For each receiver channel, this relation can be described by 3 calibration parameters: the receiver gain g, the system noise temperature T_R and the non-linearity parameter α.

$$U_{det} = g\,(T_{SC} + T_R)^{\alpha}$$

The complete G5 series of RPG radiometers is based on a calibration procedure with two blackbody targets and an internal noise diode for additional noise injection. The "hot" blackbody target is realized by a foam absorber inside the radiometer housing. The blackbody emission at ambient temperature serves as calibration reference. The physical temperature is measured with an accuracy of 0.1 K by a sensor inside the target. The "cold" calibration point is provided by RPG's newly developed precision target **PT-V2**[1]. This target is externally mounted to the radiometer. Like for the ambient temperature target, a foam absorber is used, now cooled by Liquid Nitrogen (LN2). The cold target provides an absolute brightness temperature accuracy of $\pm 0.1\,K$. During the calibration procedure the internal scanning mirror is used to point the receiver antennas toward each target.

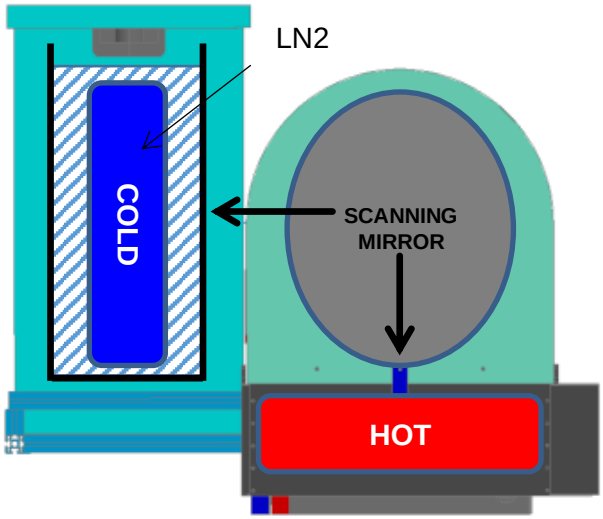


Fig. 4.3.1: General setup for absolute calibration.

[1] Two different versions of the precision target are available: 1) The standard version for all instruments with receiver channels below 100 GHz, 2) A smaller sub-mm version for all models with channel frequencies above 200 GHz.

G5 receivers use fast noise switching procedures. This means during measurements an internal noise diode is referenced at high frequency. The additional noise that is injected into the signal path is characterized by a high temporal stability. This means it can be used for continuous adjustment of receiver gain variations. The noise diode is calibrated during the absolute calibration procedure. The determined noise diode temperatures T_N complete the set of calibration parameters.

4.3.1 External Cold Calibration Target

The cold calibration target PT-V2 is made of a white foam material container with the blackbody absorber nested inside. Before an absolute calibration the container is filled with LN2 and the blackbody absorber is cooled down to the well-known boiling point of LN2[2]. For better handling the foam container is encased by an aluminum casket with a lid on top. The lid, combined with the thick sidewalls of the white foam container, insulates the LN2 from the environment. This minimizes the evaporation of LN2 and the entrainment of atmospheric oxygen.

The metal casket has an observation windows at one of the large side walls. The target's observation windows include an anti-reflection coating, which prevent reflections and the development of standing waves between the receiver and the calibration target.

Fig. 4.3.2: Cold calibration target PT-V1 container (left) and blackbody absorber (right).

[2] 77.2 K at standard atmospheric pressure. The correct boiling point is calculated form the pressure value that is provided by the integrated weather station.

4.3.2 Mounting of the Cold Calibration Target

For the calibration procedure, the target is positioned on a dedicated table. Like the target, the table is part of the standard equipment delivered with RPG radiometers. The table is mounted on the side of the radiometer housing (red arrow on housing). First remove the protective screw and the handle (if applicable) from the radiometer housing and mount the table to the radiometer housing by fixing it with the little metal poles (see photos). Now fix the screw which is attached to the table.

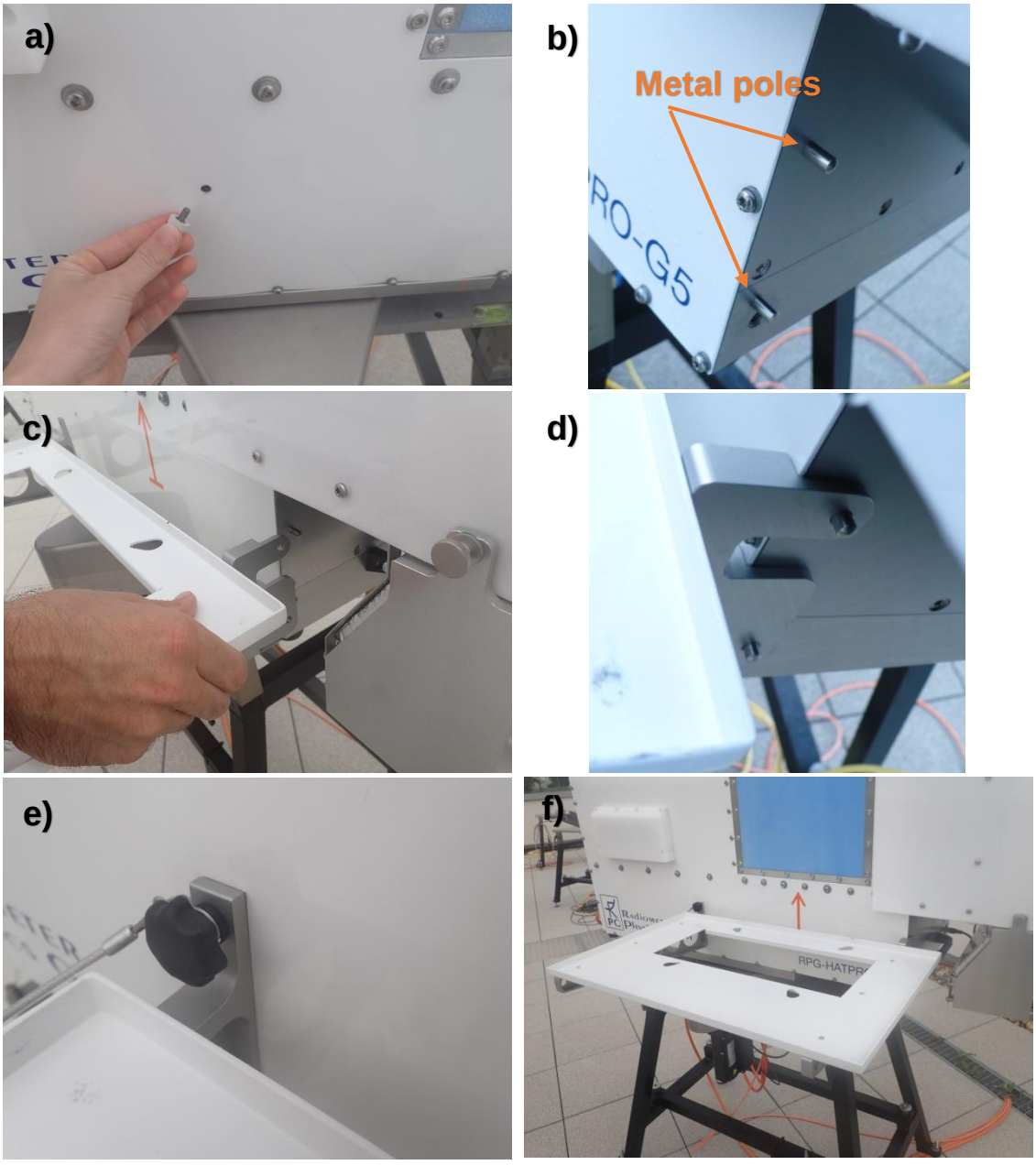


Fig. 4.3.3: Mounting of the cold load calibration target.

4.3.3 The Calibration Procedure

The cold calibration target needs filling of about 20 liters of LN2. We recommend having at least 25 liters available for each calibration. The target weight after filling requires the handling by two people for safety reasons.

Note: Handling liquid nitrogen without protection like gloves, goggles, aprons etc. is risky and can lead to serious injuries. We strongly recommend wearing these protection items while doing the calibration. Only trained personal should be allowed to handle LN2.

When filling the calibration target with LN2, the black foam inserted in the target needs to be completely covered by LN2. This will leave about 5 cm space between the LN2 surface and the top of the target, reducing spilling of LN2 when transporting it.
Close the lid, fasten it with the rubber fasteners, and carry the target with two persons to the radiometer, and lift it on the table. Make sure that the cold target observation window marked with “K/V-Modul” is facing the radiometer.

Fig. 4.3.4: Fill the calibration target with LN2 wearing suitable gloves, goggle and apron, check the filling level, close the lid, and fix the rubber fasteners.

Fig. 4.3.5: Place the target on the table. Make sure that the target's sidewall marked with "R1" is facing the radiometer.

After the target has been set up, initiate the absolute calibration procedure by clicking  (***Perform Absolute Calibration***) within the Host-PC software.

When using G5 radiometers you have to ensure that the check-box ***PT-V2 Target*** for the new calibration target is activated. In this case, the integration time on each target is set to 100 s.

The "***Start calibration***" button will commence the calibration procedure. The heater will be activated and the dew blower will turn to high-speed to avoid condensation on the target. To allow the blower and heater to remove dew that possibly formed on the target, the user will be prompted to wait 60 seconds before hitting the "***Continue"*** button.

During the calibration process the current activity is displayed in the message line. If the error message "***No response to cold load. Calibration terminated!***" appears, the cold target was probably not filled with liquid nitrogen or was not installed at all.

The message "***No noise diode response. Calibration terminated!***" indicates a malfunction of one of the noise sources. Contact RPG for help in this case.

The calibration procedure for the new target consist of 2 observation cycles:

1. ambient temperature target
2. cold target

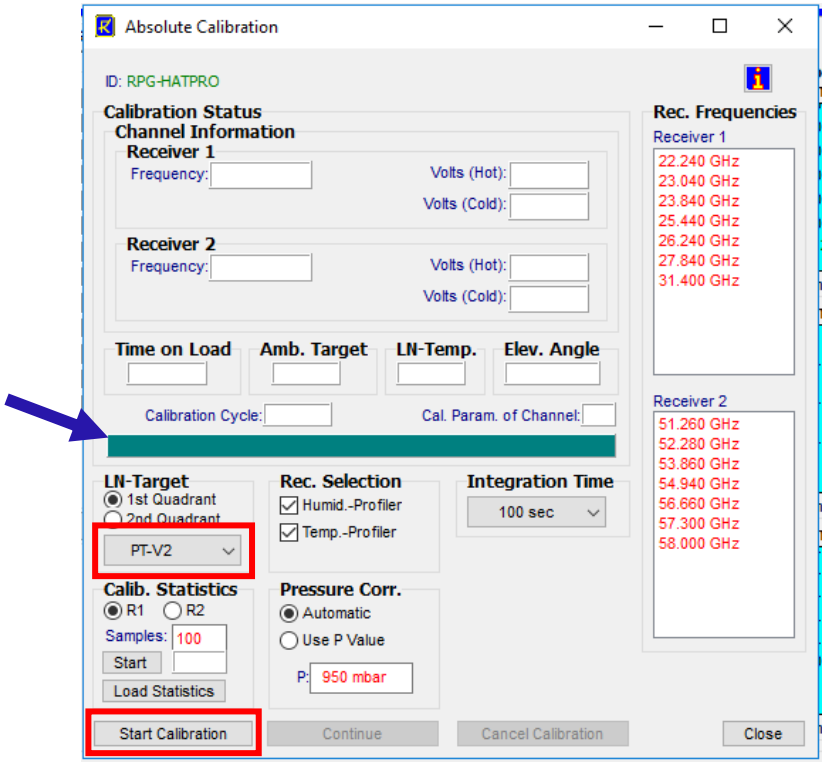


Fig. 4.3.6: Choose the target PT-V2 from the drop-down menu. The button Start Calibration starts the absolute calibration procedure. The dew blower will switch to high-speed mode and the heater will be activated. This prevents condensation of water vapor on the target observation window facing the radiometer. Follow the instructions displayed in the message line (indicated by a blue arrow).

Fig4.3.7: After calibration and dismounting of the calibration target, make sure that the protection screw is inserted again.

After the integration cycles have completed, the calibration parameters will be calculated. The message **"Calibration successful! Save?"** is displayed. Before confirming the calibration results the calculated parameters shall be checked for consistency with the former calibration. Particularly the system noise temperatures shall be examined carefully. In case these values have changed by more than 10 K within 6 months (recommended repetition rate of absolute calibrations), there might have been a problem with the calibration process or with the receiver hardware. In this case please contact RPG for further assistance.

If the results look fine, calibration parameters are stored on the Radiometer-PC by pressing **"Continue"**.

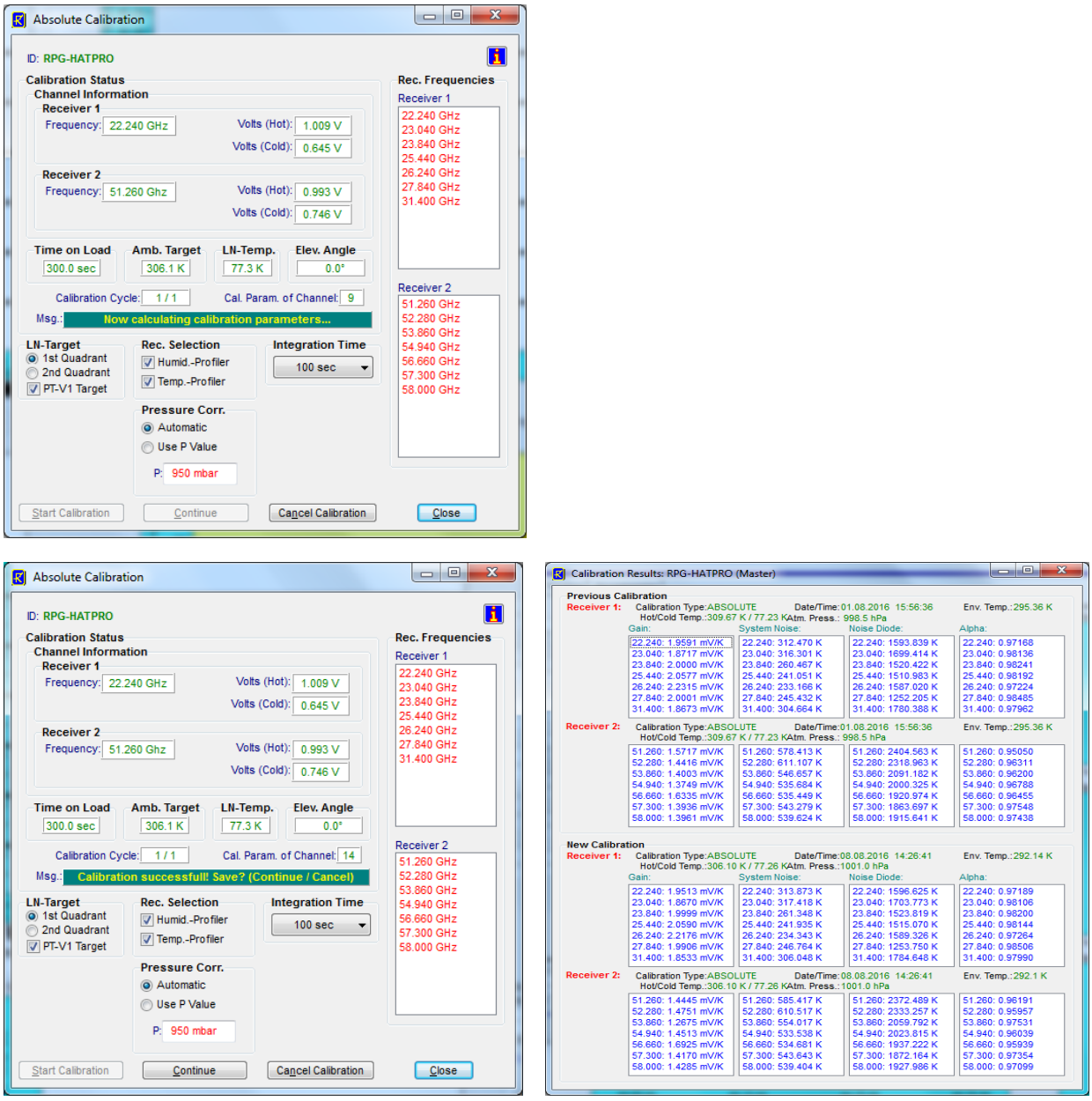


Fig.4.3.8: When the calibration process is complete, the new calibration parameters are shown and can be saved by pressing continue.

4.4 Exchange/Replacement of Parts

The instrument user is expected to exchange spare parts, which are accessible from the outside (without opening the radiometer housing), by himself. These parts are:

- **GPS receiver**
- **Radome window sheets**
- IR radiometers (if available, optional hardware)
- Weather station
- Azimuth positioner (if available, optional hardware)
- Dew blower unit
- Heater unit for dew blower
- Cables

Those parts not printed in boldface in the above list were handled during the installation process and are covered in the appropriate section of chapter 2. In the following, this maintenance guide will explain how to exchange those parts which are usually not handled during a standard installation procedure.

4.4.1 Vaisala weather station

4.4.1.1 Cleaning

To ensure the accuracy of measurement results, clean the transmitter when it gets contaminated. Remove leaves and other such particles from the precipitation sensor and clean the transmitter carefully with a soft, lint-free cloth moistened with mild detergent. Wipe with soft cloth or sponge and rinse with clean water.

Vaisala recommends that you clean the radiation shield once a year. Clean the radiation shield with a soft cloth. If the radiation shield looks worn and yellow, you can replace it with a radiation shield

4.4.1.2 Replacing PTU Module

The PTU module contains separate sensors for pressure, temperature, and humidity measurement. Vaisala recommends changing the PTU module every two years. Follow the instructions contained in the Vaisala WXT530 Series user guide delivered with the radiometer. The PTU module shall be purchased directly from the manufacturer: https://store.vaisala.com/

4.4.2 Changing the GPS Receiver

The sensor data connection needs to be dismounted by

1. loosening the connector screw of the cable connection
2. loosening the M4 mounting screws with a Torx tool (size 20)
3. detach the sensor

The replacement part is mounted by reversing the sequence of steps. In order to prevent damage to the cable connector, please comply with these rules:

- The pins usually fit easily into the socket of inside the radiometer wall. Do not apply force! If it does not go in easily, then there is some misalignment, canting, etc. Using force will destroy the pins and/or damage the socket
- The screw on the cable should only be fastened with the hand, not with pliers

4.4.3 Changing the Microwave Window Sheets

4.4.3.1 Purpose of the Microwave Window

The microwave window sheets are made from a plastic foam material which is transparent in the microwave region to allow the reception of electromagnetic radiation in the otherwise metallic shielding of the instrument's housing. The material has a thickness of 10 mm and serves as a rain protection and also thermal insulation layer. The sheets are covered with a hydrophobic coating which lets water drops roll off easily (in conjunction with the airflow provided by the blower system).

4.4.3.2 When to Change the Microwave Window

If one of the two functions of the window (protection from water, and avoidance of drops staying on the window) is no longer working because the window sheet is either physically damaged, or the coating has been worn off (by aging, salt and dust coverage, UV radiation…), then the window sheet needs to be changed.

4.4.3.3 Window Changing Procedure

Before changing the window, make sure that you are equipped with sufficient tools. We recommend a Torxs-M4 (size 20) tool, a thread cutter, an Allen key (hexagon socket screw key) with a round hat, some lubricant/grease, and a cutter.

In a first step, the old window has to be removed. Therefore, all M4 Torxs screws at the inside rows of screws (closer to the window, not the line of screws closer to the metal housing) have to be removed (Fig. 4.4.1 b). This way, the metal bands which press and hold the window sheet can be removed. If a screw brakes off, it has to be removed later by drilling it out.

In a second step, the threads inside the housing frame need to be prepared for re-mounting: All threads need to be cleaned from debris and lubricated. A thread cutter is dipped into the lubricant and then turned into each of the threads (Fig. 4.4.1 c)

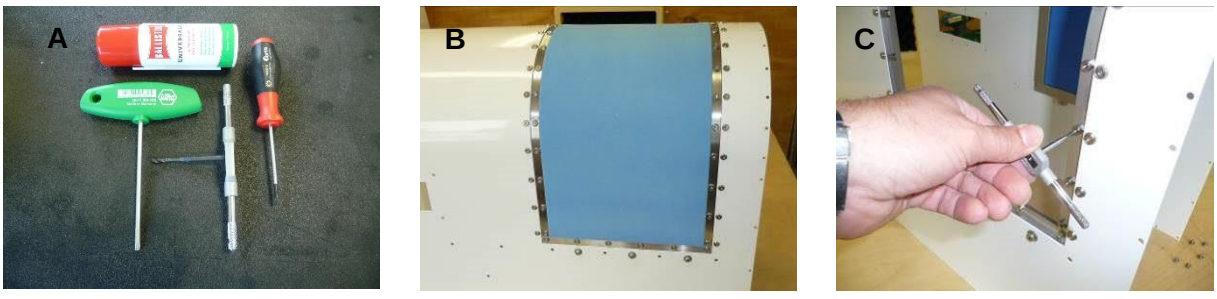


Figure 4.4.1 a, b, c

The metal bands for re-mounting the window sheet need to be arranged carefully to their respective positions since they are **not symmetric!** Figures 4.4.2 (d, e, f) show that the **smaller distance** between the holes and the edge of the strip located in the side of the **window**, the larger distance to the side of the metal housing.

Figure 4.4.2 d, e, f

The mounting procedure starts with placing the replacement windows with the already existing triple set of holes symmetrically over the topmost thread in the radiometer housing (Fig. 4.4.3 g). The metal strips are placed over the window sheet and fixed by fastening the Torx screws.

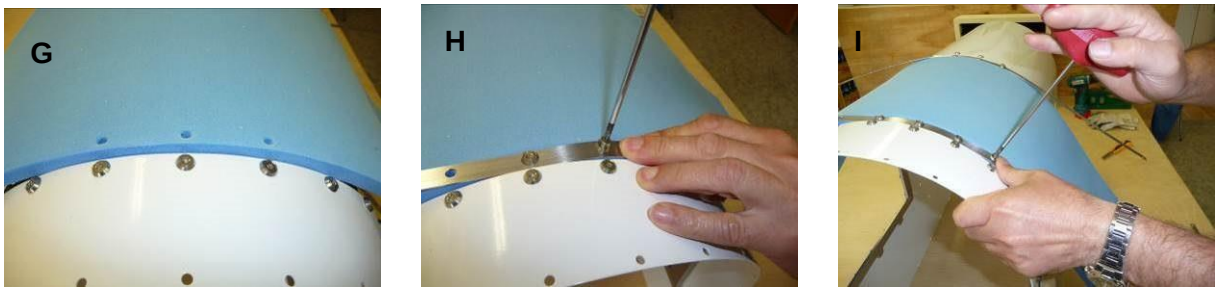


Figure 4.4.3 g, h, i

A small Allen wrench (size M3) is used to punctuate the window sheet material at the position of the next holes (Fig. 4.4.4 L). While working from screw to screw from top down to the lower side of the housing, some force needs to be applied to pull the metal bands tight and apply enough pressure to squeeze the window material into position (Fig. 4.4.2 m, and o). The last screw at the bottom of the long metal strips shall not be completely tightened now.

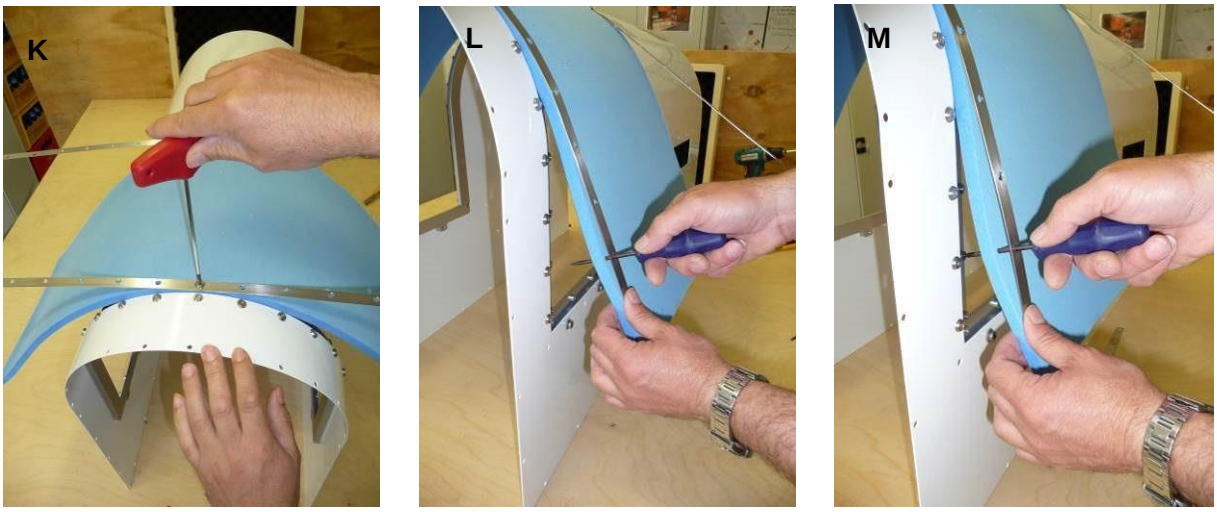


Figure 4.4.4 k, l, m

The pulling of the metal bands is best done with a small Allen wrench, putting the head into the holes of the mounting threads as a counter bearing (as a toe hold). The tool should have a round head, so that the thread is not damaged.

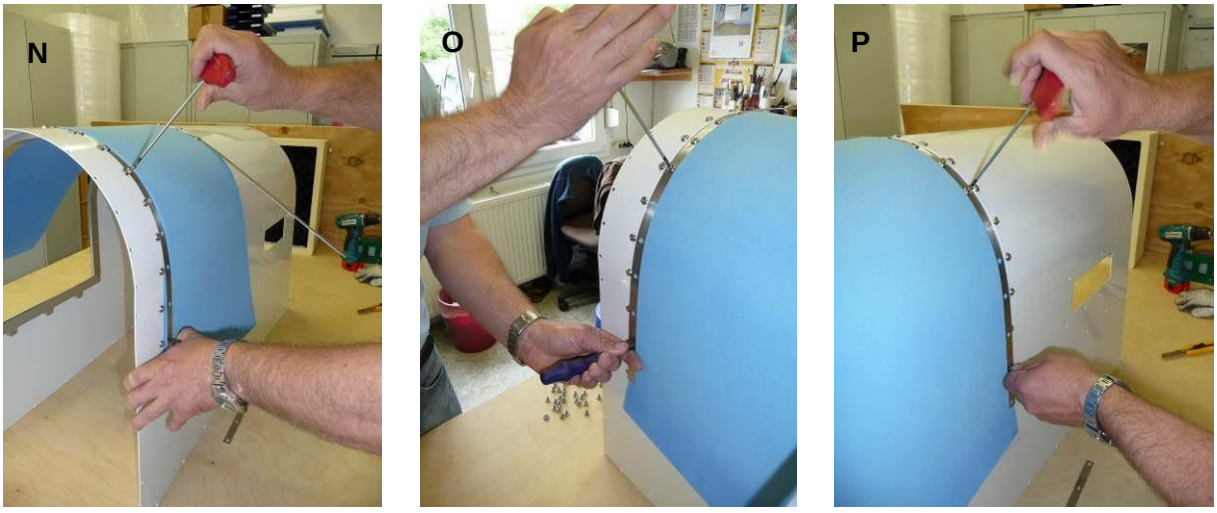


Figure 4.4.5 n, o, p

After applying the two longer metal strips over the arch of the radiometer housing (Fig. 4.4.5 p)., there will be extra material of the window sheet at both lower side which needs to be cut off and removed. Figures 4.4.6 q, r, and s show how to use the remaining shorter metal bands for marking and cutting the surplus material with a cutter.

Figure 4.3.6 q, r, s

After cutting the excess material, the window sheet is finally fixed with the short metal bands at the lower sides. After the short bands are fixed, the screws at the bottom of the long metal bands may now be tightened.

Figure 4.4.7 t, u, v

In the end, the window material should be firmly pressed to the metal housing frame, without leaving any gaps (Fig. 4.4.7 u, v).

4.5 Preventive maintenance

In the table below the given maintenance intervals are average periods. Depending on the deployment site these intervals should be optimized. For instance required cleaning intervals strongly depend on climate zones (arctic, sub-tropic, etc.), the vicinity to polluted areas (cities, sand deserts, airports etc.) or the abundance of insects or other animals (e.g. spider webs).
See section 4.1 Cleaning) for instructions on how to clean the various radiometer parts. Section 4.4 Exchange/Replacement of Parts contains the instructions to exchange the GPS receiver and the consumables (radome sheets and PTU sensor of the Vaisala weather station).
Cables inspection consist in a check for damaged insulation and corrosion of connectors.

Activity	Recommended Service Interval
Cleaning of weather station	6 months
Cleaning of dew blower	6 months
Cleaning of radiometer housing	12 months
Cleaning of microwave window	6 months
Cleaning of cooler slits	24 months
Cleaning of IR radiometer mirror	6 months
Absolute calibration with liquid nitrogen	6 months
Inspection of cables	12 months
Exchange of microwave window	6 months
Exchange PTU module of the Vaisala weather station	2 years

5 Trouble Shooting

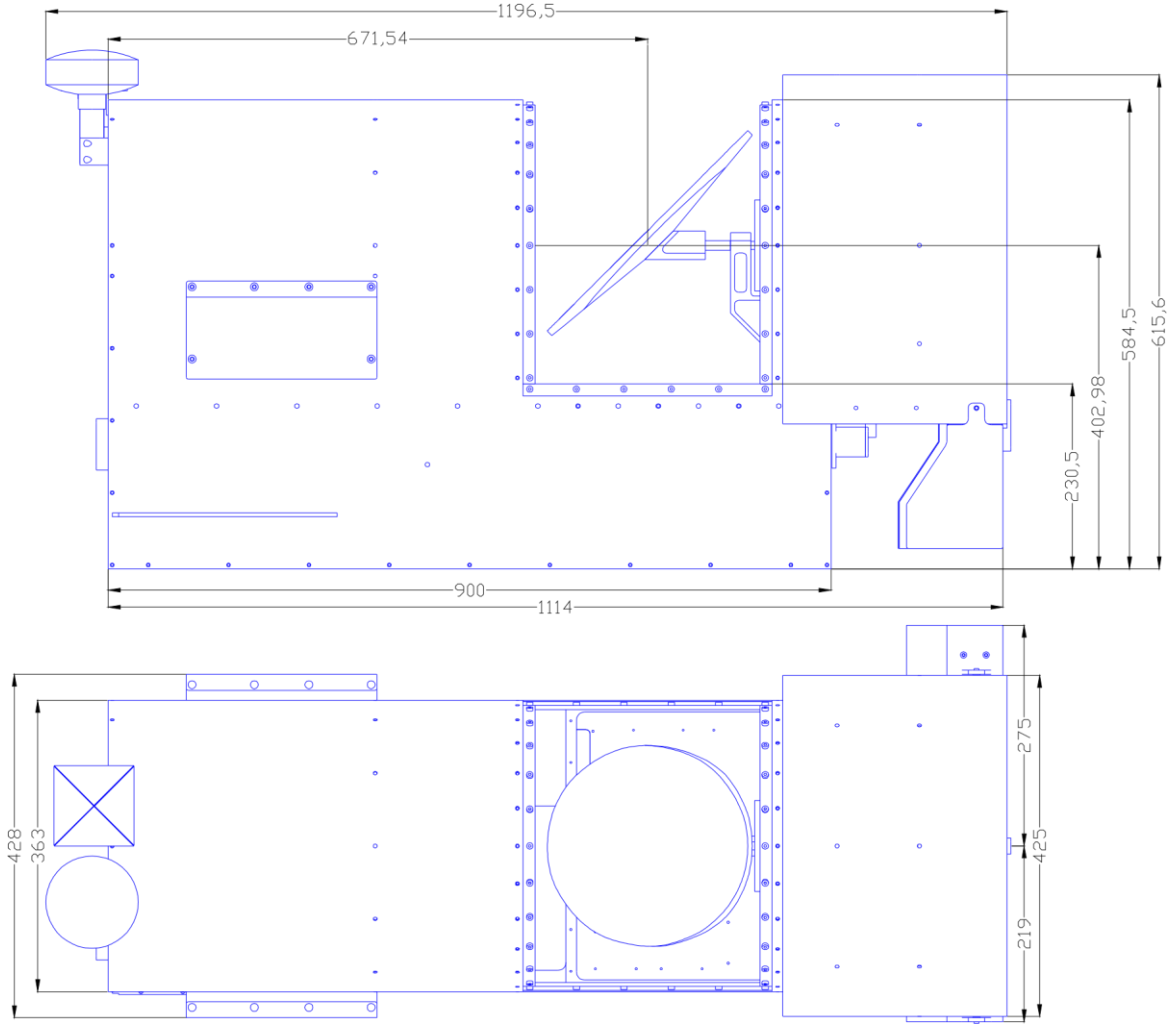
problem	possible cause	what to do
host connection to radiometer cannot be established	A) bad cable inter-connection B) radiometer PC software has crashed C) host PC interface damaged D) radiometer PC interface damaged E) radiometer not turned on	check all connectors for cleanliness and correct fitting, data cable(s) damaged? Fiber optics cable connected correctly? reset radiometer PC (turn on/off or use reset button) replace host PC contact RPG turn on radiometer power and wait one minute for booting
measured LWP and IWV values unrealistically high	wet radome (microwave window)	dry the radome replace window set lower humidity threshold for heater module switching (see Software Manual)
interference (RFI) on one of the reception channels	external high frequency source (e.g. radar, data link, etc.)	use retrievals for level 2 data that are not including the disturbed channel, contact RPG
brightness temperatures show strong drift	A) receivers are not thermally stabilized B) thermal control system malfunction	wait for a warmup period of 45 minutes check receiver temperatures in diagnostics menu (see Software Manual), contact RPG
brightness temperatures show spikes	A) external RFI source B) external obstacle (person, bird, etc…) C) channel malfunction	Remove external source or scan to different direction remove external obstacle contact RPG
message “Measurement finished” in UNLIMITED mode	A) radiometer power failure and radiometer’s recovery mode is turned off B) someone manually terminated measurement	activate radiometer recovery mode (see Software Manual)
rain flag always on or off	sensor malfunctioning	Replace weather station

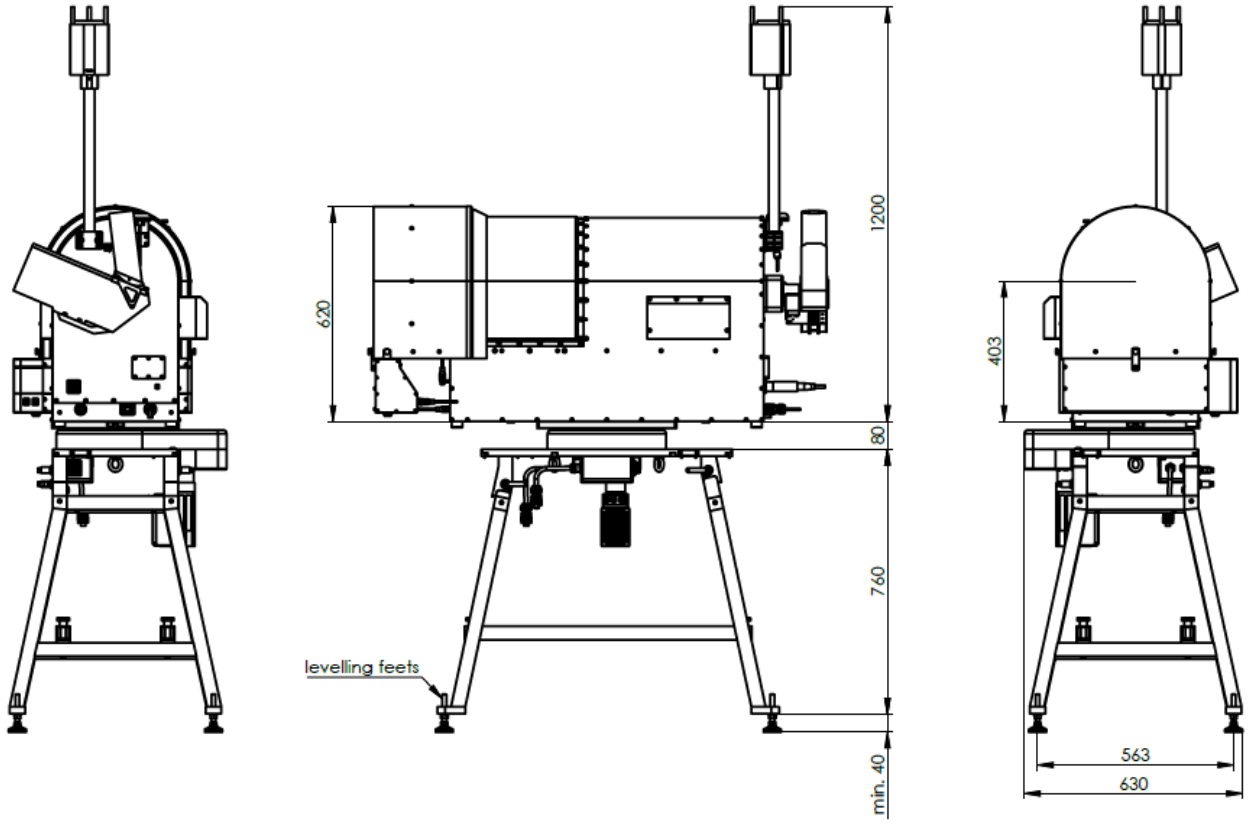
problem	possible cause	what to do
surface temperature or humidity shows unrealistic temperature	sensor malfunction	Replace weather station
damaged microwave window	birds, ice, vandalism…	replace microwave window (ask RPG for replacement window sheets)
blower always on high speed	humidity threshold for blower high speed and activated heater module too low	increase rel. humidity threshold (see Software Manual)
blower does not work	A) blower not correctly connected to radiometer B) radiometer power off C) blower malfunction	check blower connecting cable turn on radiometer power contact RPG
sky tipping always fails	A) clear sky conditions, inhomogeneous humidity field B) RFI in one of the transparent channels	wait for better atmospheric tipping conditions try other azimuth angles for the elevation tipping, delete the elevation angle (where the disturbance occurs) from tipping list (see Software Manual)
message “No response to cold load” during absolute calibration	A) no liquid nitrogen in external target or no target attached to radiometer box B) one of the receiver channels has failed	install external cold target and fill with liquid nitrogen. Repeat calibration check channel responses in diagnostics menu (see Software Manual), contact RPG
message “No response to noise diode” during absolute calibration	A) one of the channels has low signal level B) the noise diode of one of the calibrated receivers has failed	check channel responses in diagnostics menu (see Software Manual), turn on/off noise diode manually, contact RPG

6 Spare part list

Spare part	Part Number	Change Interval	Reason for change
Heater Module	40007105	4 years	maximum lifetime (assuming 50% duty cycle)
Dew Blower Motor	40005503	5 years	average lifetime (assuming 50% duty cycle)
Dew Blower (complete)	40007104	--------	mechanical damage due to mishandling
Radome Sheet (microwave window)	41009000	6 months	hydrophobic coating performance degradation over time
GPS-Clock	41004200	--------	part failure
Data Cable (50 m) (fibre optical)	41000017	--------	mechanical damage due to mishandling
Power Cable (50 m)	41000021	--------	mechanical damage due to mishandling

7 Radiometer dimensions

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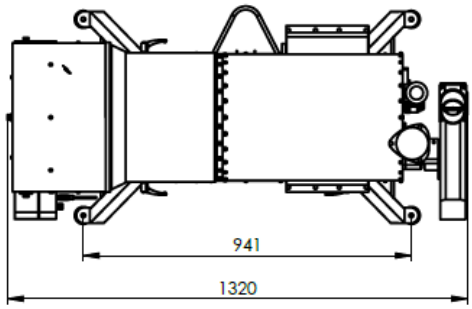
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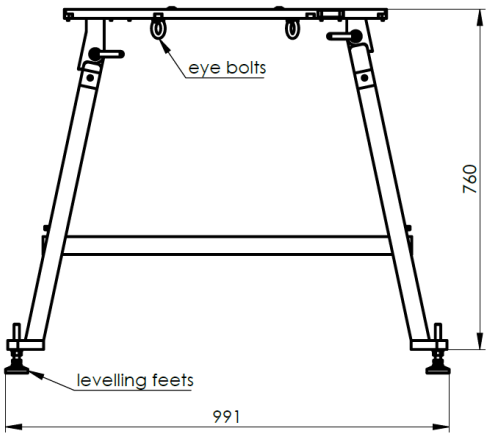
eye bolts
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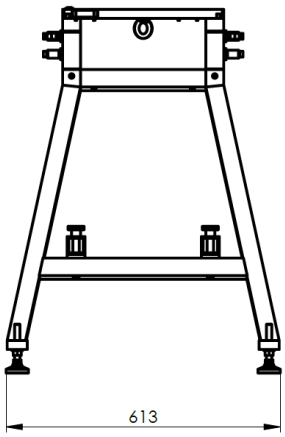
613