User manual

Imprint

SwisensPoleno Mars user manual

Swisens AG

English

	SwisensPoleno Mars user manual
Valid for:	® SwisensPoleno Mars
Valid for Version:	01-2021
Edition:	3nd edition March 2022
Date of creation:	10th March 2022

Table of contents

1. Safety and security

1.1. General understanding of safety

The SwisensPoleno measuring station is designed to be safe and poses no hazard when used as intended. For proper operation of the measuring station, the instructions should be read, understood and followed.

IMPORTANT: During maintenance work on the measuring station, there are dangers that can only be avoided if the correct procedure is followed.

1.2. Intended use

- The SwisensPoleno measuring station is used to measure and classify bio aerosol particles (pollen, spores etc.) and other aerosols in the surrounding air with a particle size of 0.5µm – 300µm.
- ***IMPORTANT: Only air (or otherwise an inert gas) may be aspirated, no liquids or solids >500µm.***
- The measuring station including the “SwisensPoleno” instrument can be operated at temperatures from -20°C to +50°C.
- The installed measuring station can be operated safely at wind speeds of up to 35m/s and contains protective measures to reduce damage caused by direct and indirect lightning strikes. The weatherproof housing (IP65) and the air conditioning system (IP54) are protected against solid and liquid precipitation.
- **The unit must be sufficiently fixed at the installation site to prevent it from tipping over in strong winds.**
- **The instrument is not explosion-proof. Use in connection with explosive media is not permitted.**
- **In case of misuse or manipulation of the measuring station, normal and safe operation cannot be guaranteed by the manufacturer.**

1.2.1. Intrusion protection

The weatherproof housing is supplied as standard with a Kaba© 5000 lock (half cylinder type 1514 with adjustable cams). Upon customer request, another lock (e.g. half cylinder Kaba 20 type M1514/32.5) can be installed. The door hinges are hidden and not accessible from the outside.

1.3. Operating personnel

Only qualified and trained personnel may operate the SwisensPoleno measuring station.

The necessary qualification is available if the personnel:

- has completed or is in the completion of basic technical training,
- has completed or is in the completion of a secondary technical education,
- can demonstrate knowledge in the operation of technical devices & apparatus, and/or
- has knowledge in the maintenance of technical devices & apparatus.

The operating personnel must have been trained by the manufacturer. The acceptance certificate for operating the measuring station signed by the manufacturer and the instructed person serves as proof.

IMPORTANT: Separate training is required for maintenance work on the measuring station. Only trained personnel may carry out maintenance work on the measuring station. The corresponding proof is provided by means of a separate acceptance certificate for the maintenance of the measuring station.

1.4. Modifications on the instrument

The instrument is designed to be safe. No attachments, conversions or modifications may be made which are not carried out by the manufacturer or have not been authorised by the manufacturer. The manufacturer accepts no liability for damage or accidents in connection with unauthorised attachments, conversions or modifications.

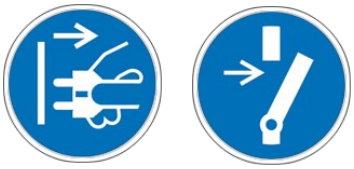
1.5. Technical condition control

Outdoor operation may cause defects at the measuring station due to special external influences, which represent a potential hazard. For example, damage to the power cable could expose live wires. If such a defect is detected, the measuring station must be switched off immediately and access secured if necessary. The manufacturer must be contacted for further instructions.

1.6. Important precautions

For extensive maintenance or repairs, parts that normally protect against hazards may need to be disassembled. In order to avoid hazards, the prescribed protective measures must be taken:

The measuring station must be completely voltage-free by switching off the instrument fuse or pulling out the mains plug.



1.7. Danger and warning information

WARNING

Class 3 laser light sources inside the measuring instrument. Exposed laser sources may damage vision or cause blindness. Disassemble instrument ONLY with power removed. Work on the laser light sources while system is in operation is not permitted! .

WARNING

Inside the measuring station there are electrical conductors and components. An electric shock can cause injury and cardiac arrest. Disassemble instrument ONLY with power removed. Work on the electronics while system is in operation is not permitted!

WARNING

The instrument is not explosion-proof. Use in conjunction with explosive media is not permitted!

Further danger and warning notices are listed in the individual chapters and descriptions.

2. Performance specification

SwisensPoleno Mars is based on the measuring principle of flow cytometry for the automatic measurement and classification of aerosol particles in the air in real time. The primary application is the detection and identification of pollen and other particles in ambient air.

The measuring instrument collects a mosaic of independent measurements of each individual particle and then classifies the various particles on the basis of these measurements. Based on the extensive data set and in combination with state-of-the-art classification algorithms, an excellent quality of the classification results is achieved.

The software included in the delivery allows at least the measurement and identification of the following pollen species found in central Europe:

Birch	Betula sp.
Ash	Fraxinus excelsior
Grass	Poaceae
Hazel	Corylus avellana
Alder	Alnus sp.
Oak	Quercus sp.
Hornbeam	Carpinus sp.
Pine	Pinus Strobus

The classification software can be extended at will (by the customer or by the manufacturer). Updates can be installed in consultation with the manufacturer.

2.1. Special features SwisensPoleno

2.1.1. Fast data access

All raw data, measurement data and operating parameters are stored in an internal database. If configured accordingly, this database can be mirrored to an external server. These data can be accessed at any time via a REST API.

Browser-based tools are available for visualization of the data. With the SwisensDataExplorer, the raw data including the associated result data or classification of the corresponding particles can be viewed in the form of single events or as concentration time-series. The recorded data also includes various system parameters to check if the instrument is operation properly.

2.1.2. Comprehensive instrument monitoring

The operating parameters can be checked periodically via the REST API using a server script. Relevant operating parameters are particle velocity, particle concentration, airflow, temperature, response time and storage space usage (not exhaustive). If a rule is violated, a pre-defined action can be triggered (e.g. sending an e-mail to the administrator) to take measures to remedy operational faults.

2.1.3. Preventive and curative measures

The unit is equipped with an integrated cleaning function that can be used to remove any nozzle blockages or deposits on the inlet grille. The periodic preventive use of the cleaning cycle prevents larger deposits.

2.1.4. Autonomous operation

The instrument software runs in docker containers, which start automatically when the system is switched on. The measuring system runs without remote access and without direct intervention by the provider. If there is no data connection, the raw data and measurement results are stored locally and transferred later. The local memory is sufficient for at least six weeks.

2.1.5. Easy maintenance

The instrument runs the SwisensPoleno Cockpit, which provides a direct insight into the operating parameters and measurement data on site. This software is mainly used during commissioning and on-site maintenance to check and ensure the correct functioning of the instrument. If access is properly set up and secured, the check can also be carried out remotely. On-site maintenance is typically only required once a year.

2.1.6. Software updates

The identification software is continuously developed further by the manufacturer. The optimization of the existing identification software is part of the maintenance. The source code of the evaluation software can be viewed and modified by the client. Extensions can be made at the customer's request.

Software and parameters are stored in versioned Git repositories. If required, updates for the repositories can be downloaded from the Swisens server or imported using file archives/patches.

2.1.7. Life time and consumables

The measuring principle and the structure of the SwisensPoleno allow the continuous operation of the measuring station without any consumables. The hardware is equipped with solid-state electronics and optics to ensure a long service life (at least 10 years).

2.2. Additional services

2.2.1. Additional weather data

The modular weatherproof housing permits the extension of the measuring station by means of external sensors. This allows additional information on particle measurements to be collected and easily integrated via the interface provided for this purpose in SwisensPoleno.

Manufacturers and products for external sensors are recommended under chapter 2.3 "Accessories".

2.2.2. Instruction for the generation of training data

Training data is required for the customer-specific enhancement of the identification software. In order to generate such training data, an instruction course is offered by the manufacturer. Alternatively, the training data can also be created by the manufacturer. The instructions for generating the training data are described in the "Training Data Generation Guide" which describes how training data can be obtained. The recommended accessory "SwisensAtomizer" is listed in chapter 2.3.2.

2.2.3. Training for maintenance and operation

If the training for maintenance and operation is not part of the purchase contract, additional training may be offered. For the maintenance and operation of SwisensPoleno, trained personnel are required to ensure proper operation.

2.3. Accessories

The manufacturer recommends the following accessories:

2.3.1. Weather sensors

If required by the individual application, additional weather sensors can be mounted externally on the weather protection housing. There is a cable duct and a mounting possibility for a pipe with 40mm outer diameter on the left outer wall of the weather protection housing to mount an appropriate weather station.

The manufacturer recommends the following products:

Smart weather sensors from Lufft:
https://www.lufft.com/products/compact-weather-sensors-293/

Compact weather sensors from Gill Instruments:
http://gillinstruments.com/products/anemometer/maximet-compact-weather-stations.html

2.3.2. SwisensAtomizer

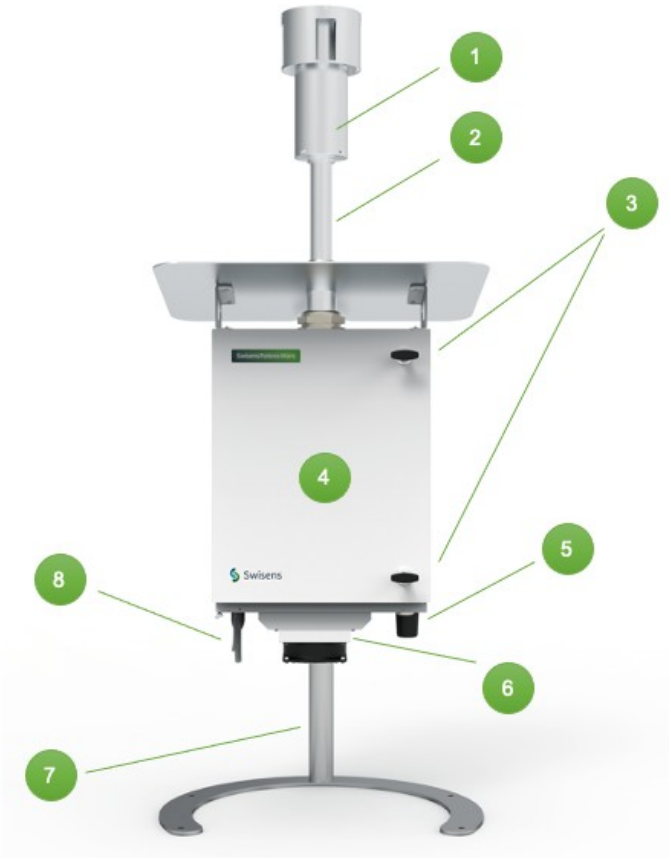
The usage of SwisensAtomizer is recommended for the process of training data generation needed for the classification software. With SwisensAtomizer, particles can be dispersed in a controlled manner and blown through an adjustable air flow in the direction of the Sigma 2 inlet.

3. Instrument description

3.1. Standard scope of delivery

Components	Number
SwisensPoleno Mars instrument with installed operating software	1
Sub construction or post mount option	1
Intake pipe incl. connecting hose and hose clamps	1
Sigma 2 inlet	1
KABA 5000 key	2
Accessories (see chapter 6.1)	1
User manual	1
Maintenance manual	1
Swisens REST API specification	1

3.2. Overview measurement station SwisensPoleno



1 **Sigma 2 inlet**
- air particles are aspirated through inlet

2 **Intake pipe**
- directs air particle stream to concentrator

3 **Door handle with lock**
- enables to open the access door to the measurement compartment

4 **Maintenance Access door**
- enables access to the measurement compartment and all electronics parts
IMPORTANT: Do not open the access door while operation. Do not touch electronic parts while operation.

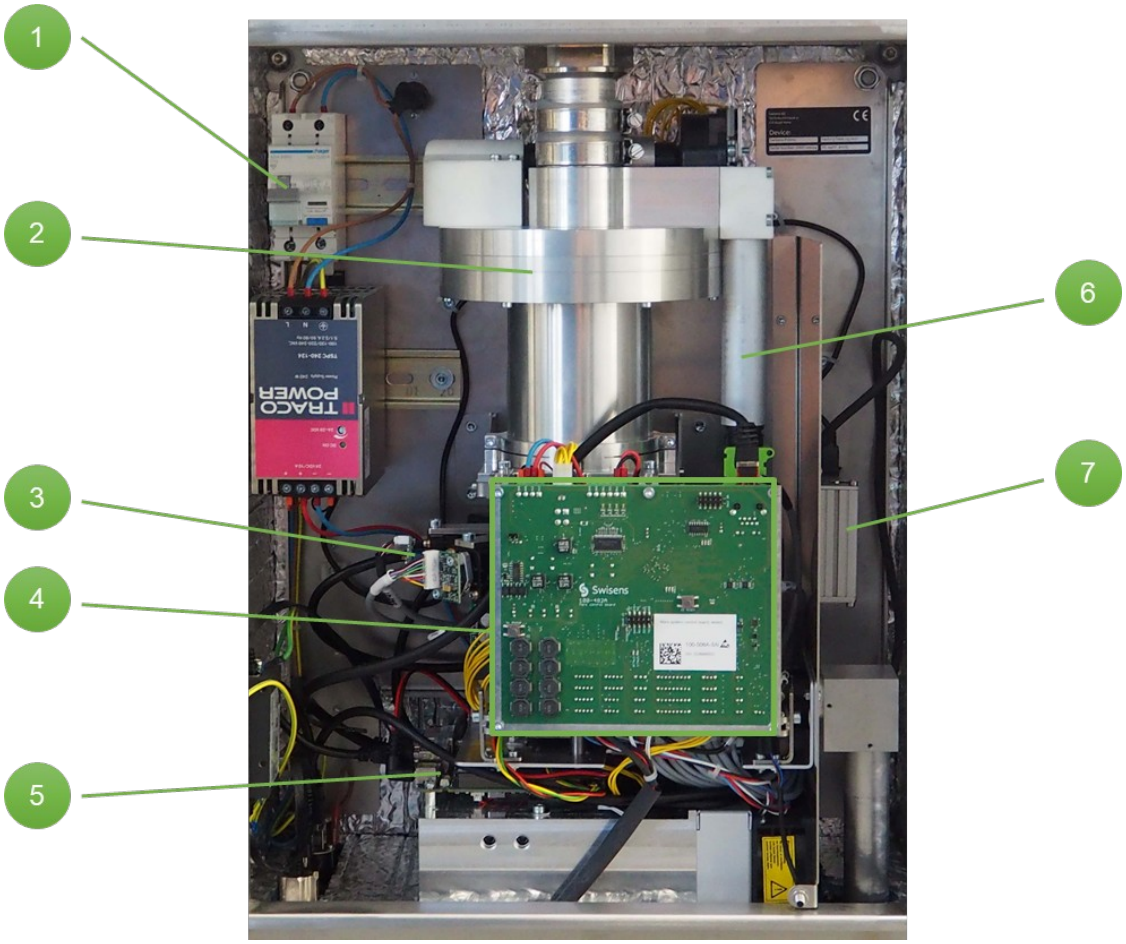
5 **GSM Antenna / Air Outlet**

6 **Air conditioning**
- for temperature and humidity regulation

7 **Mounting/Sub-construction**
- for different mounting options of SwisensPoleno Mars

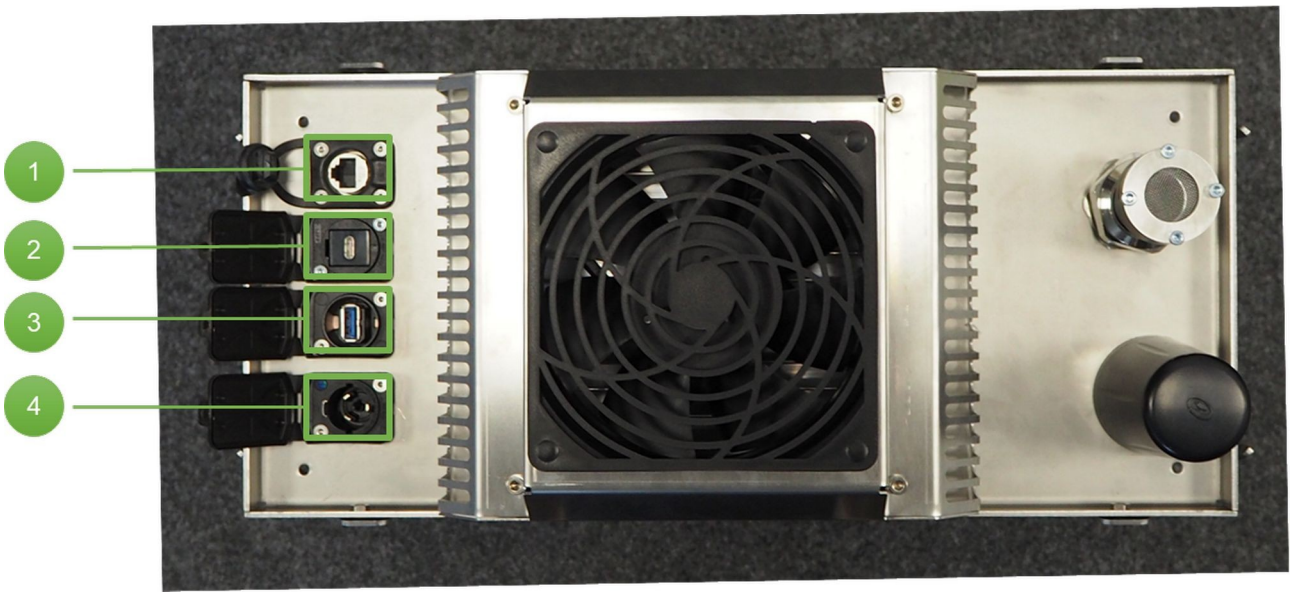
8 **Connection plugs**
- for USB-C, Ethernet and External Power

3.3. Interior of SwisensPoleno Mars



1. Safety Switch/Power switch
2. Particle concentrator
3. Measuring chamber with optical measuring equipment
4. Main electronics board
5. Integrated industrial computer (IPC)
6. Bypass air tube
7. Mobile router

3.4. Connection plugs of SwisensPoleno Mars



1. Ethernet connection
2. USB-C 3.2
3. USB-A 3.2
4. Power Connection Plug

3.5. Software

3.5.1. SwisensPoleno Cockpit

The SwisensPoleno Cockpit is the brand new web based user frontend. With the SwisensPoleno Cockpit no additional software for VNC is required anymore. It appears in a timeless and intuitive design and allows simultaneous access to multiple monitoring systems in the network, by simply using tabs in your preferred web browser (a recent version is required).

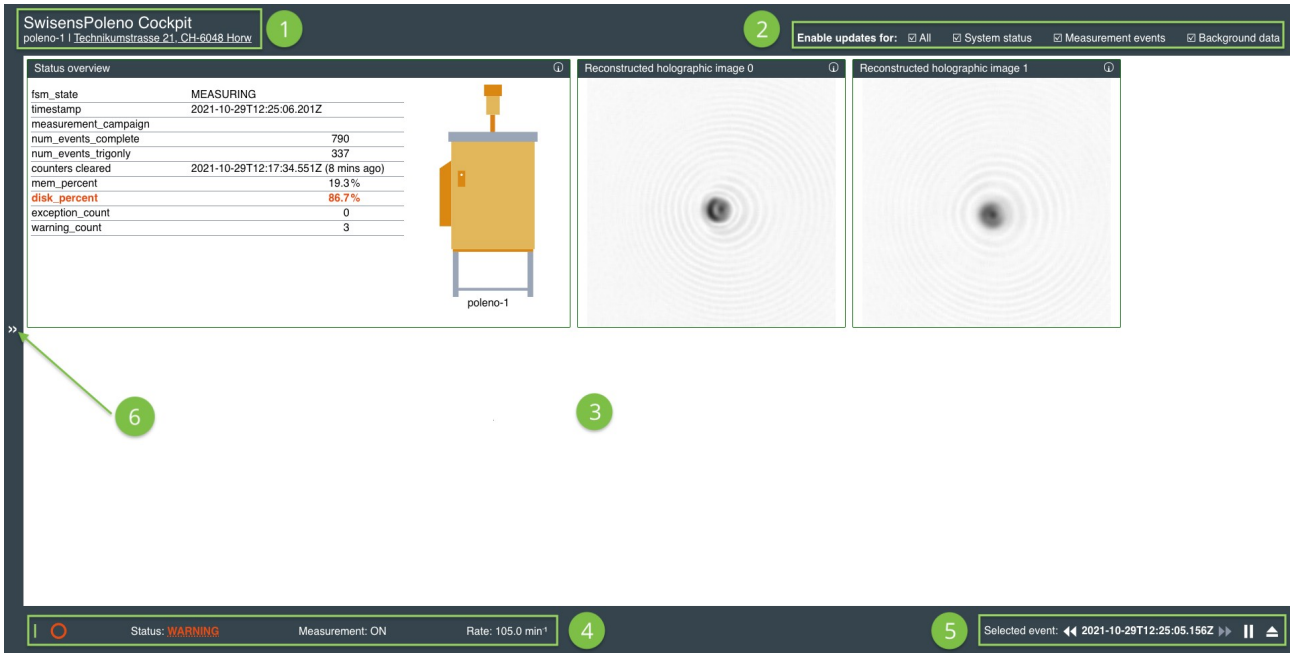
The new user-interface gives an immediate indication of the overall system status with a green, yellow and red color code.

- **Green:** System runs normally
- **Yellow:** Abnormal operating conditions have been detected, which could result in degraded performance and may cause failure
- **Red:** Error conditions have been detected and the system is most probably not measuring correctly anymore

In addition, the modular elements of the user interface enable customized views tailored to the user and/or application. With the SwisensPoleno Cockpit we are giving access to a large set of system status information if needed. At the same time it provides quick and easy access to check the performance of your system in your monitoring network.

The screenshots on the next page will guide you through the interface.

Default interface after login



1. Identification information about the connected instrument

2. Choose what data shall be updated and shown in the Cockpit in real-time. Disable individual setting in case they are not necessary to reduce the bandwidth usage, e.g. when using a mobile internet connection. All settings are enabled by default.

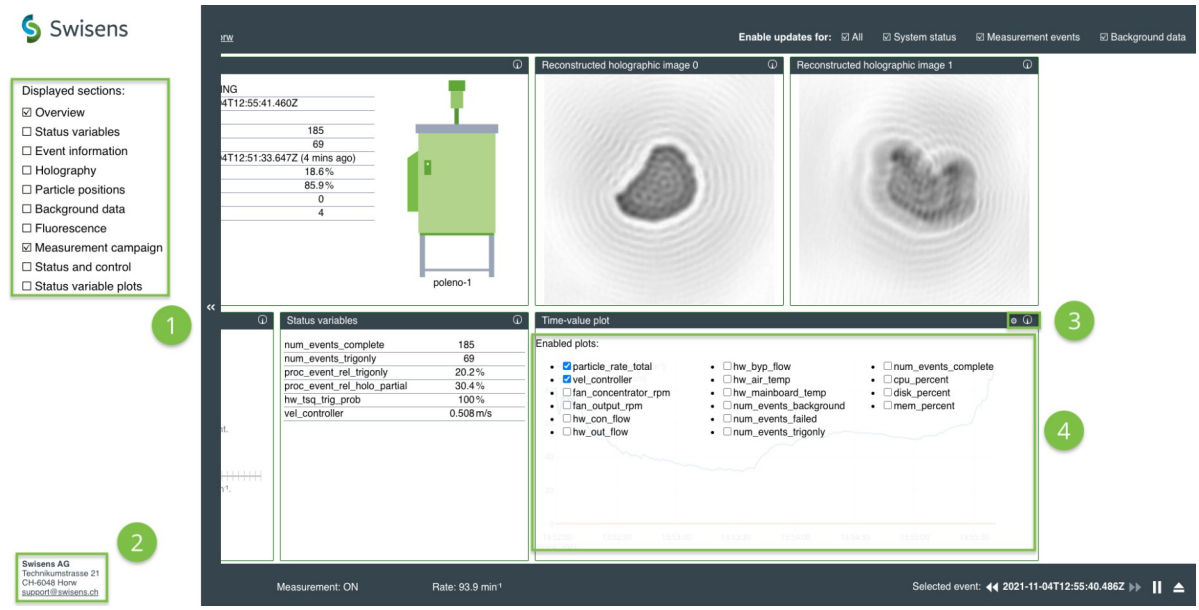
3. Default information board after login. Can be extended using sidebar selection.

4. Basic indication from left to right:
   - Start/Stop instrument,
   - System status with warning condition(s) pop-up window on hover
   - Measurment acquisition status
   - Current particle detection rate

5. Event selection from left to right:
   - select previous and next buffered event,
   - toggle tracking of most recent event
   - clear all events from the buffer

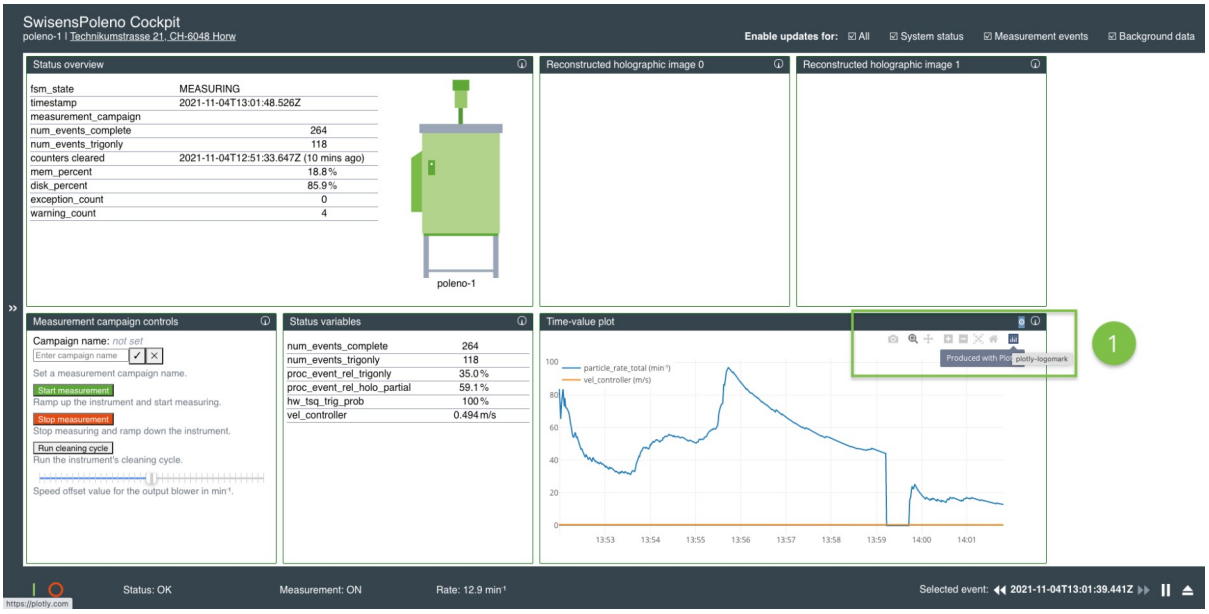
6. Sidebar selection for choosing displayed sections in the information board (hover to open)

Sidebar with displayable sections



1. Select sections to be visualized on the information board to the right
2. Contact information of Swisens customer support
1. Click on the gear wheel to open plot selection pop-up window
4. Select data for plot visualization

Adjust plot visualisation

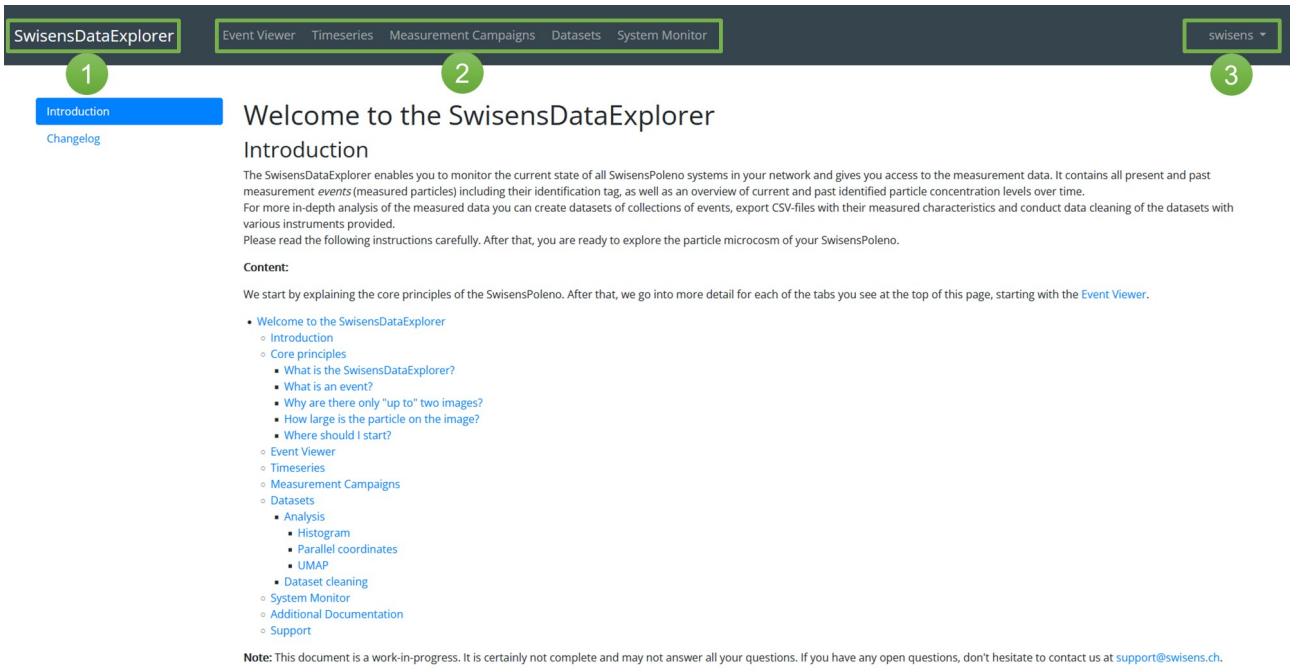


1. Hover over top right corner of plot window to adjust plot visualisation and to download as a png

3.5.2. SwisensDataExplorer

The SwisensDataExplorer enables you to monitor the current state of all SwisensPoleno systems in your network and gives you access to the measurement data. It contains all present and past measurement *events* (measured particles) including their identification tag, as well as an overview of current and past identified particle concentration levels over time.
For more in-depth analysis of the measured data you can create datasets of collections of events, export CSV-files with their measured characteristics and conduct data cleaning of the datasets with various instruments provided.

Main Page



1 Link to Main page with documentation and changelog

Note: For the latest documentation on SwisensDataExplorer please refer to this online documentation integrated into SwisensDataExplorer.

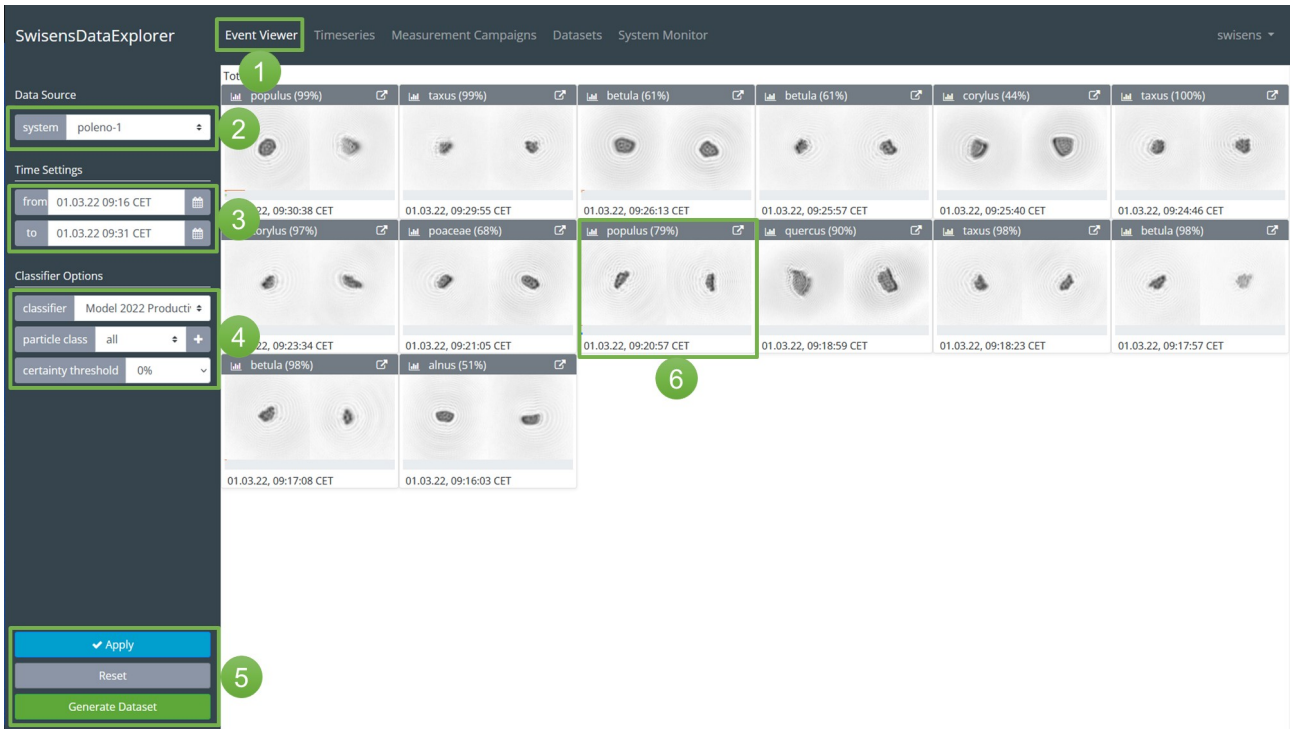
2 Tab selection
- Event Viewer
- Timeseries
- Measurement Campaigns
- Datasets
- System Monitor

3 Profile settings

Event Viewer

The Event Viewer shows what events are currently measured or have been measured by your SwisensPoleno. In the Event Viewer tab you can adjust the following settings:

- select the system by choosing a SwisensPoleno in your network
- select the time range you want to observe (past 15 minutes by default)
- select the classification algorithm from your system (default not specified)
- set a filter for known particles classes (default all)
- set a certainty threshold to be applied to the events (only events with a higher probability are shown)



1 Selection «Event Viewer»-Tab

2 Instrument selection

3 Selection measurement time period

Note: only select small time ranges (for example 15 minutes) as the total amount of displayed events can get very high with bigger time ranges.

4 Selection of classification model / classifier, particle class and certainty threshold

5 Apply: Load and display events according to the settings

Reset: reset settings

Generate Dataset: Generate a dataset out of all the events selected by the current settings.

6 For each event the two reconstructed holography images are displayed. Click to open the image in a new tab.

Left: display information of the selected identification algorithm for this event (if event was classified by the identification algorithm)

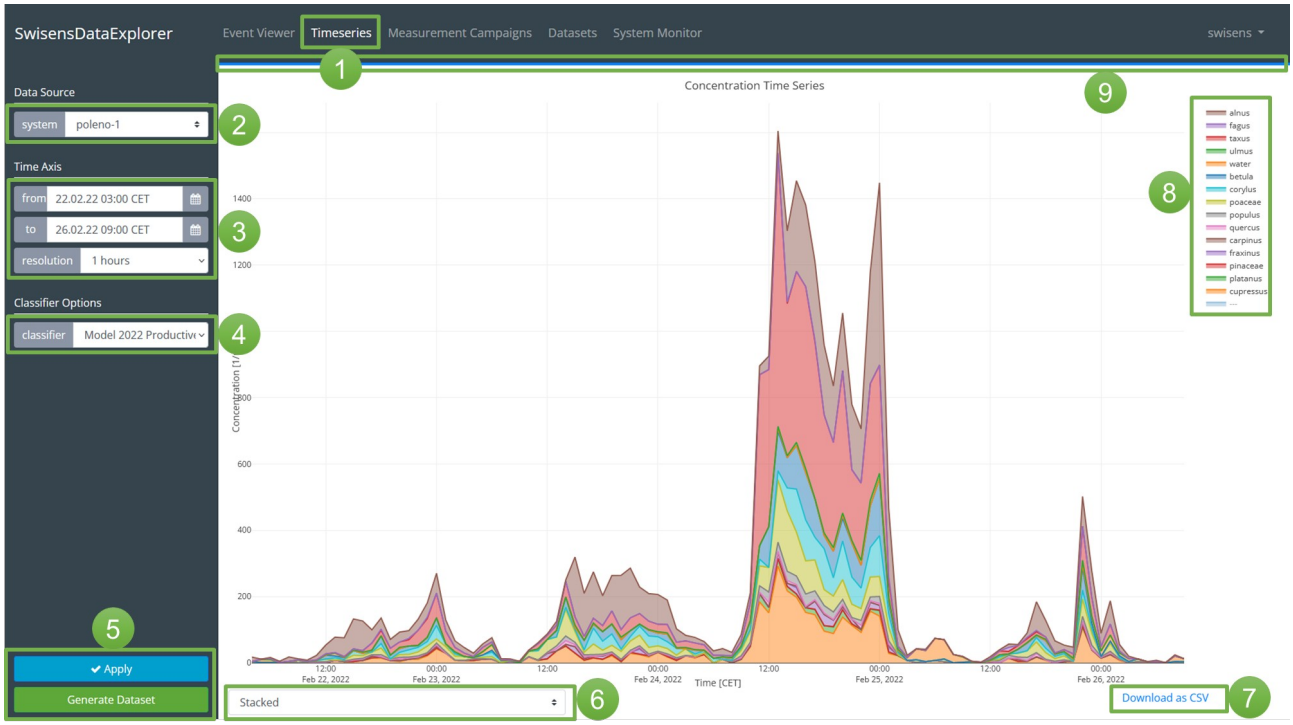
middle: identification result

right: access to JSON-formatted measurement data for the particle

Timeseries

Within the Timeseries tab you can visualize the changes in concentrations over time for different aerosol particles, which were identified with a classification algorithm. In the Timeseries tab you can adjust the following settings:

- select the system by choosing a SwisensPoleno in your network
- select the time range you want to observe (past 24 hours by default)
- adjust the resolution if necessary (1 hour by default)
- select the classification algorithm (default not specified)



1 Selection of «Timeseries» tab

2 Instrument selection

3 Selection of time period and time resolution

4 Selection of classification model / classifier

5 Apply: Evaluation based on the selected options will be started. The progress will be displayed in (9).

Generate Dataset: Generate Dataset out of all the events matching the selected settings.

6 Change the type of plot (lines, stacked, normalized)

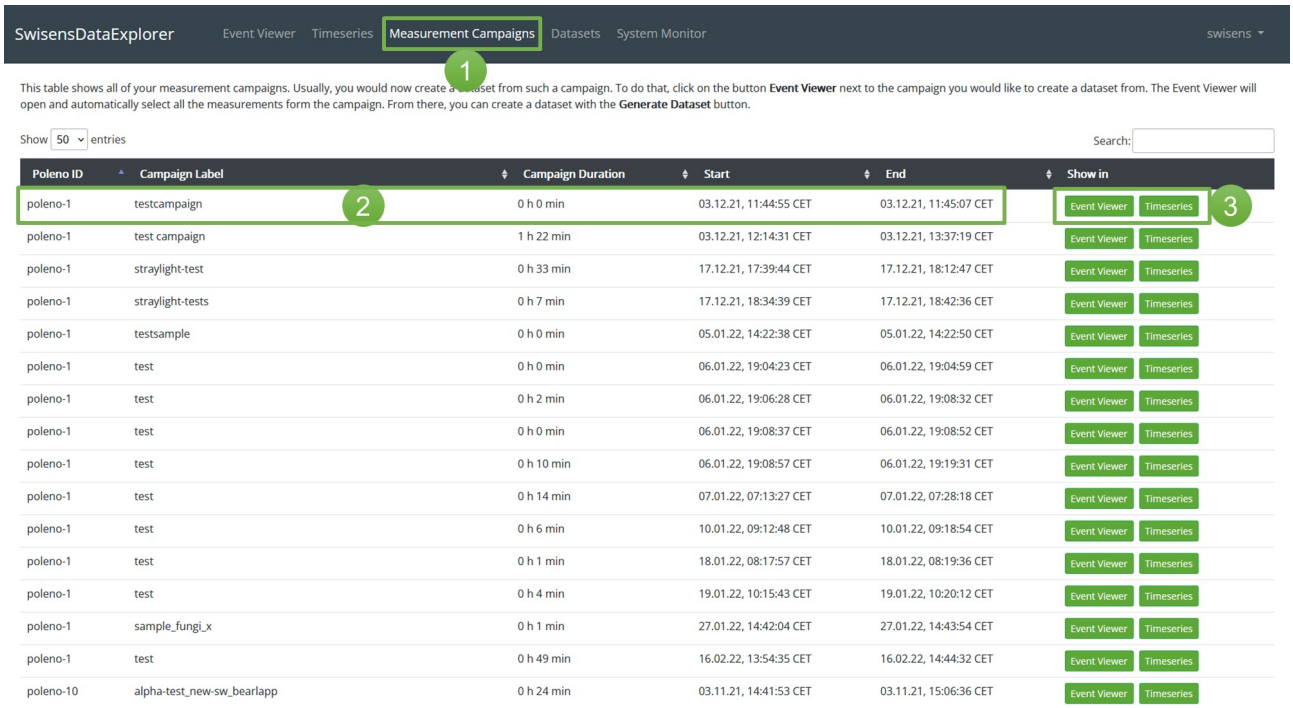
7 Download the displayed timeseries as CSV-file

8 Legend. Enable or disable a certain label by clicking on the legend entry.

9 Display of progress of evaluation

Measurement Campaigns

After conducting a measurement campaign with your SwisensPoleno(s) it gets listed in the Measurement Campaigns tab with the label you provided, the measurement system ID, the campaign duration and the start and end time. To view the events you measured you can simply click on the Event Viewer or Timeseries button.



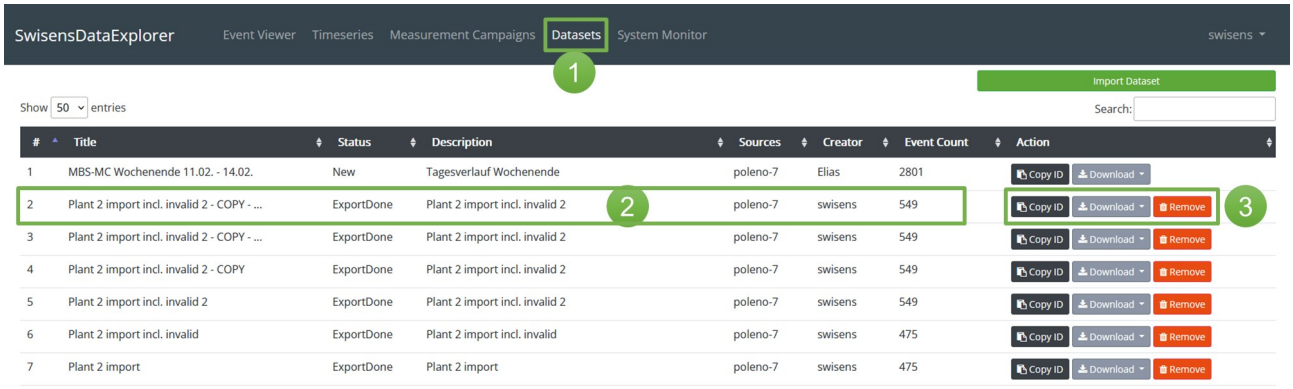
1 Selection «Measurement Campaigns»-Tab

2 Campaign Label entry

3 Show the labelled events either in the Event Viewer or the Timeseries Tab.

Datasets

Datasets are collections of events bundled together. Each dataset contains measurement events from one SwisensPoleno.
Datasets are intended for further analysis of a set of events or for the training of machine learning algorithms. The SwisensDataExplorer provides tools to clean and analyse the datasets.

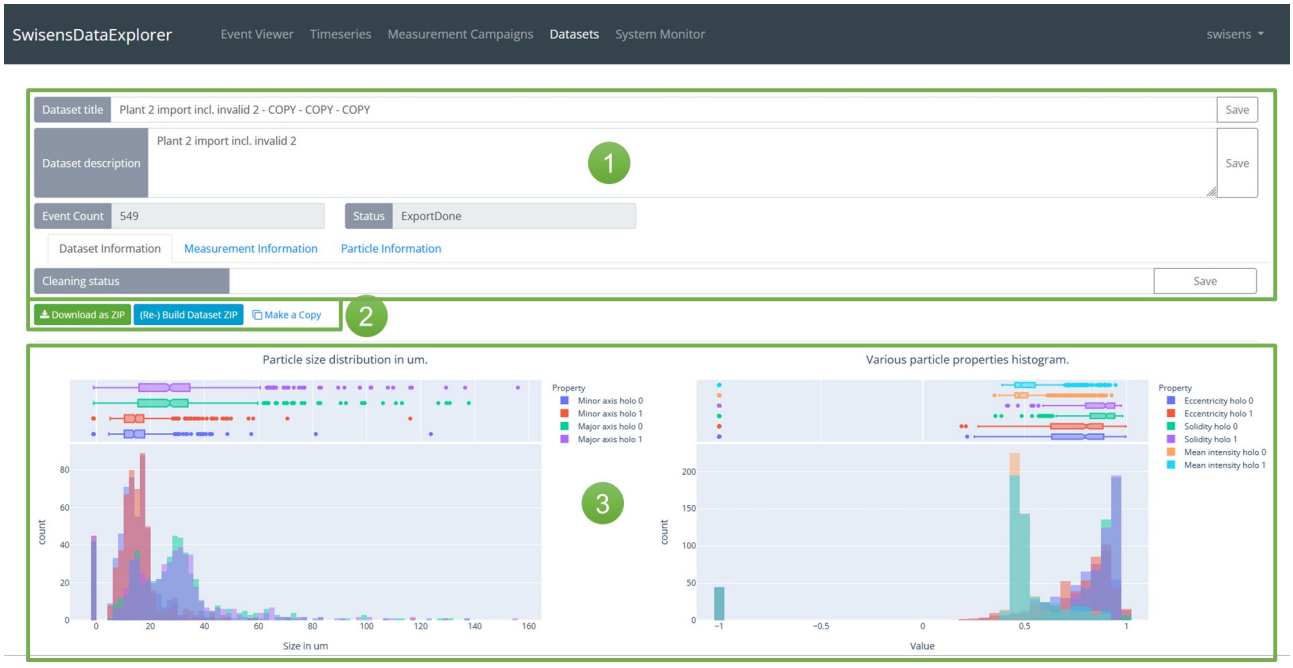


1 Selection «Datasets»-Tab

2 Selection of an existing dataset – click to open the dataset in a new window

3
- Copy Dataset-ID
- Download a CSV- or ZIP-file
- Delete dataset (events contained in the dataset will not be deleted from the database)

Dataset Analysis



1 Information about the dataset

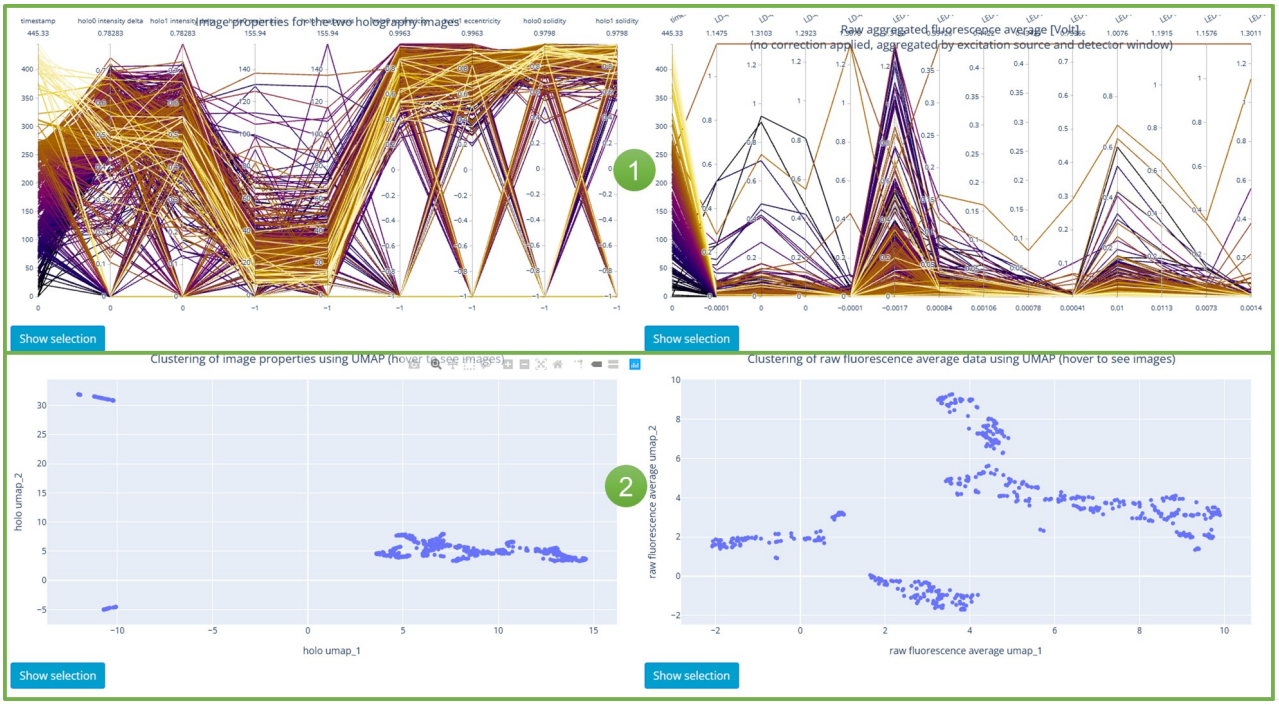
Note: It is recommended to make the description as detailed as possible so that no questions arise at a later stage.

2 Create a copy of the dataset – for example for further cleaning.

Download the dataset event data as ZIP file or as CSV file in tabular form.

3 Size distribution of the particles in the dataset

Note: If the size distribution is not displayed, the button “Do Analysis” has to be pressed once.



1 Parallel Coordinates Plot – clean the dataset due to particle properties like the grayscale intensity, eccentricity or major axis of the two images per event.

Note: If plots are not displayed, the button “Do Analysis” has to be pressed once.

“Show selection” applies the filters selected in the parallel coordinates plot to the dataset and only displays the events corresponding to the applied filters.

2 UMAP plot – select individual events and clusters with the lasso-function.

Note: If plots are not displayed, the button “Do Analysis” has to be pressed once.

“Show selection” applies the selection in UMAP and only displays the selected events.

1 Scatter plot particle positions shows the position where the particle passed through the measurement channel - select individual events or region with the lasso-function.

Note: If plots are not displayed, the button “Do Analysis” has to be pressed once.

“Show selection” applies the selection in the scatter plot and only displays the selected events.

2 Mark events which are currently displayed for deletion from the dataset by pressing “mark selected for deletion” or mark individual events by manually clicking on the (-) in the “actions” column. Events selected for deletion will be marked with a red background in the event list.

By pressing the “apply changes” button all marked events (red background) will be deleted from the dataset.

System Monitor

The System Monitor enables you to see the internal working parameters of your SwisensPoleno(s). The selected parameters are plotted over time.

1. Selection «System Monitor»-Tab
2. Search for a certain parameter in the property-list.
3. Time selection for plot – press apply after time selection.
4. Open the currently displayed time period in Event Viewer or Time Series Tab. The time range can be changed by zooming the x-axis.
5. Plot of the events happened during the selected time range (for example start/stop of measurement and cleaning cycles).
6. Plot of the selected system parameters

4. Description of work to be carried out for the installation

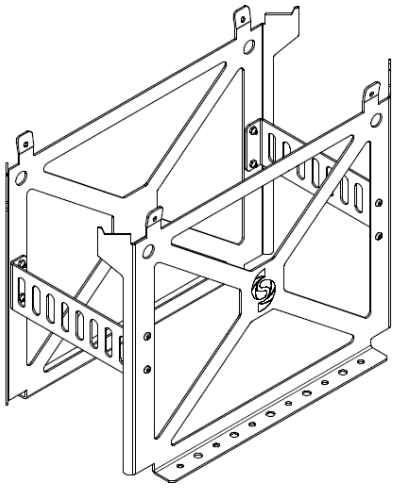
4.1. Installation guide

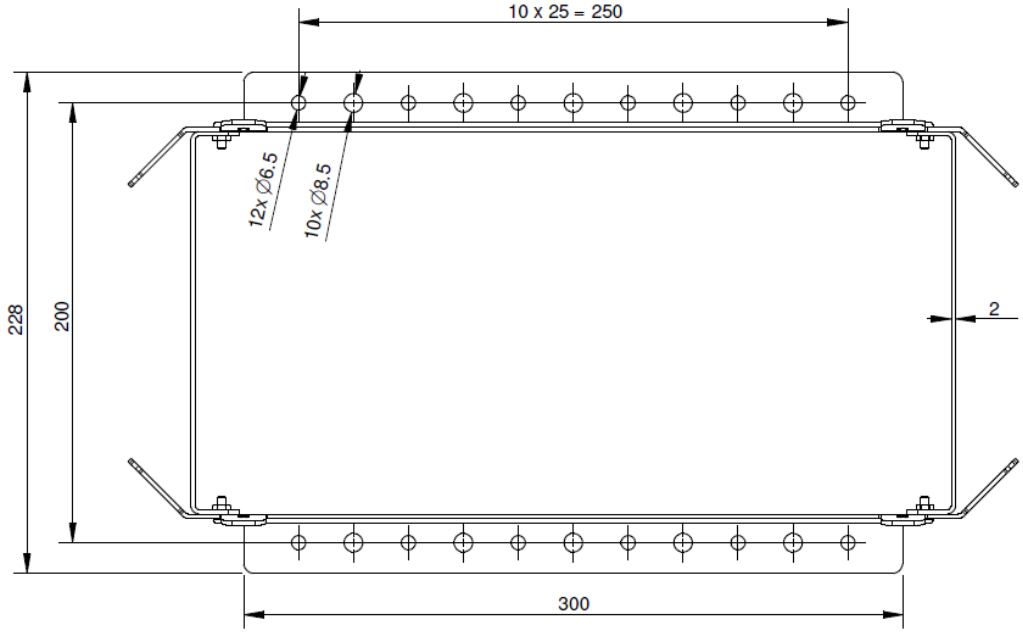
4.1.1. General information before installation

The total weight of a complete measuring station for outdoor operation is 34kg.

At the destination a level place with 0.45m x 0.45m floor space, possibilities for four fixing points, 230VAC 50/60Hz 9A and a grounding terminal for the lightning conductor is required. Other voltages on request.

The base frame has multiple holes (diameter 8mm) for fixing the instrument to the floor (see figures below).





Alternatively a post mount adapter can be used to mount the instrument on a post.

The instrument has a mobile router (4G) incl. antenna as interface for the transmission of measurement and system data. Alternatively, an RJ45 feed-through in the bottom of the housing allows a wired connection to an Ethernet LAN. Power is supplied via a mains cable which is routed through the bottom of the housing.

IMPORTANT: The unit must be sufficiently fixed in place to prevent it from tipping over in strong winds.

4.1.2. Unpacking of SwisensPoleno Mars

For unpacking SwisensPoleno Mars open the transport box cover. You will see the first foam inlay with components needed for the installation and additional accessory such as the SwisensAtomizer.

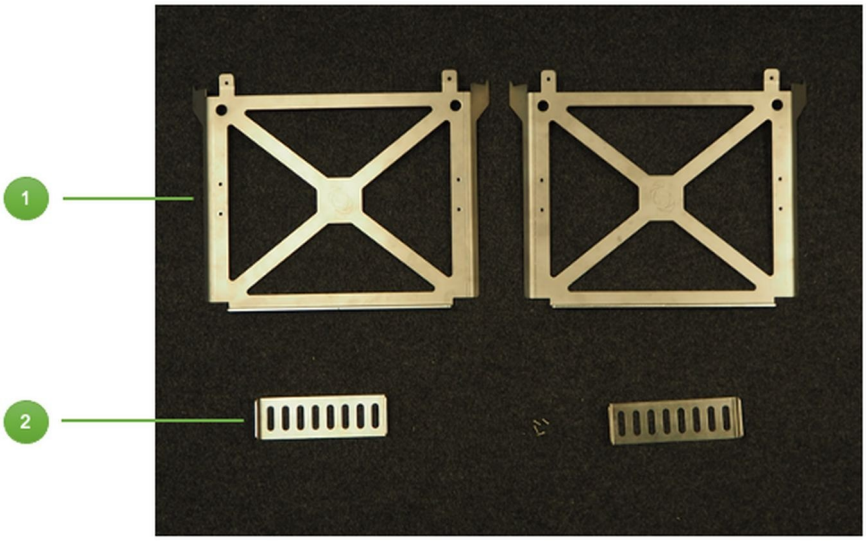
Note: The image below is for reference only. The contents may vary depending on individual configuration and orders.

Remove all components first, then remove the foam inlay.

1. Sigma-2 geometry inlet
2. Intake pipe
3. Installation rack

Preparation and assembly of installation rack

Before removing SwisensPoleno Mars from the transport box, assembly the installation rack as followed:

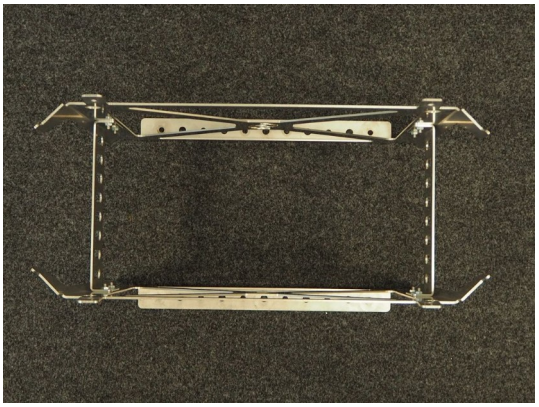
- 

Prepare the installation rack components as shown

(1) mounting support

(2) cross struts

- *Assembly the two cross struts with the mounting supports with the attached screws and nuts.*



Tools	Number
Screw driver	1
Set of fork wrenches	1

Removal of SwisensPoleno Mars from transport box

Objective: The installation rack is prepared and the instrument can be removed from the transport box.

Important note: Do not place the instrument on the air conditioning.

Remove the instrument from the transport box and place it on the installation rack.

Note: The installation rack can also be used for permanent mounting the instrument on the ground.

Fix the instrument to the installation rack with the associated screws.

Tools	Number
Screw driver and screws (4pcs.)	1

4.1.3. Assembly of SwisensPoleno Mars

Objective: The measuring instrument is assembled and ready for installation

Preconditions: ***IMPORTANT: The installation rack must be** prepared **before starting with the assembly of SwisensPoleno Mars. For more information follow the steps in chapter 4.1.2.***

- *Remove SwisensPoleno Mars from the transport box and place it on the installation rack.*

- *Have the weather protection roof, the pipe and the fork spanner ready*

- *Loosen the pipe fitting with the fork spanner supplied and insert the pipe*

- *Mount the silicon hose and two hose clamps onto the suction pipe of the measurement instrument. Then place the inlet pipe through the pipe gland. Lower the inlet pipe (leave approx. 2mm air gap between suction pipe and inlet pipe of the instrument) and connect the two pipes with the silicon hose.*

  Tighten the hose clamps with a ratchet or a slotted screw driver.

- *Place the weather protection roof onto the roof mounting. Attach the roof with the appropriate screws and plastic washers.*

  Tighten the two pipe fittings with the fork spanner supplied.

- *Attach Sigma-Inlet onto the inlet pipe*

Tools	Number
Supplied fork spanner	1
Set of fork wrenches	1
Set of ratchet wrenches	1
Flat screwdriver	1

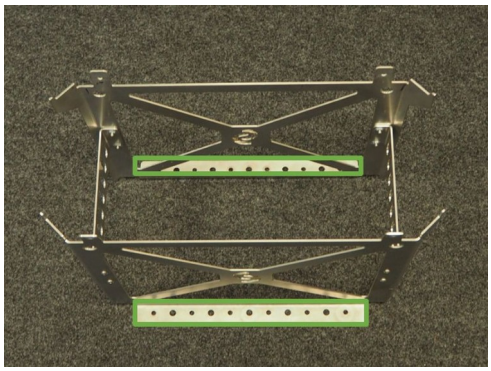
4.1.4. Installation of SwisensPoleno Mars on site

Objective: The completely assembled instrument is prepared for installation on site.

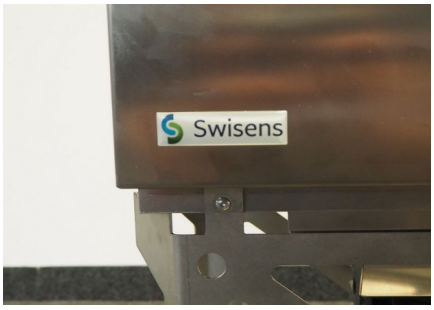
Mounting of SwisensPoleno Mars with installation rack

Preconditions: ***IMPORTANT: Make sure the installation rack is assembled as described in chapter 4.1.2***

- *Mount the installation rack onto the ground by using the dedicated wholes (diameter 8mm) as shown in the picture below. Use at least 2 screws per side to fix the installation rack to the ground.*



- *Place the SwisensPoleno Mars onto the installation rack and attach it by using 4 allen key screws. Tighten the screws with an allen key.*

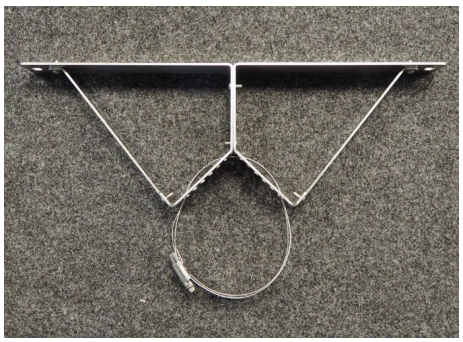


-
  - *Place the clamp with lightning conductor attachment around the intake pipe*
  - *Fasten the lightning conductor wire to the clamp and lead it downwards along the weatherproof housing.*
  - *Mount the lightning conductor wire to the ground terminal.*

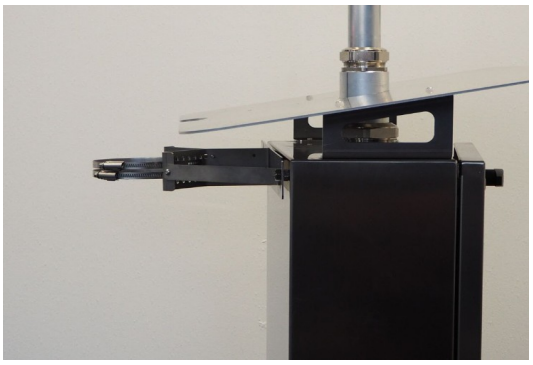
- *Connect SwisensPoleno Mars*
  - *Plug in the power connection*
  - *Plug in the ethernet connection*
  - *Plug in external screen (USB-C) for comissioning*

Mounting of SwisensPoleno Mars by post mount adapter

Preconditions: ***IMPORTANT:** Make sure the both post mount adapter together are prepared as shown in the picture below.*



- *Attach each post mount adapter, one at the top and at the bottom on the back of the instrument housing, by using two nuts.*



- *Loosen all tube clamps, lift the instrument at the post and wrap the tube clamps around the post. Tighten the tube clamps by using a ratchet until until the instruments fits tight to the post.*
-
  - *Place the clamp with lightning conductor attachment around the intake pipe*
  - *Fasten the lightning conductor wire to the clamp and lead it downwards along the weatherproof housing.*
  - *Mount the lightning conductor wire to the ground terminal.*

- *Connect SwisensPoleno Mars*
  - *Plug in the power connection*
  - *Plug in the ethernet connection*
  - *Plug in external screen (USB-C) for comissioning*

4.1.5. Ensuring Internet Connection

Objective: Internet connection is available either through ethernet cable or mobile rounter.

Providing connection over ethernet cable

To establish a connection over an ethernet cable just plug in the cable. The SwisensPoleno device will try to get an IP automatically. Alternatively a fixed IP can be set in the settings.

Outgoing port 1195 should be available. If necessary the mac address of the system has to be unlocked (ask Swisens for the MAC address).

Providing connection over integrated mobile router

Insert an appropriate SIM-Card as described in the mobile router manual (Teltonika TRB140; https://teltonika-networks.com/downloads/en/trb140/TRB140-Datasheet.pdf).

Connect to the mobile router by a laptop and ethernet cable and check internet connection

Configure mobile router if necessary. The mobile router can be accessed as follows:

- IP: http://192.168.2.1
- PW: same as SwisensPoleno system

Switch ethernet cable from the bottom ethernet cable connector to the mobile router

4.1.6. Start-up of SwisensPoleno

Starting up the measuring station and function test

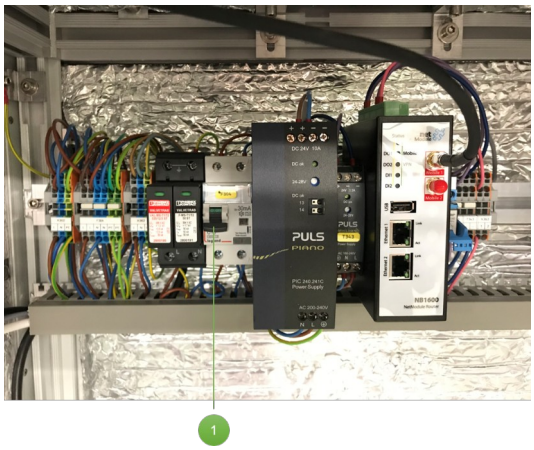
Objective: The completely installed measuring station is prepared and started for control operation. After completion of the work, the measuring station is in operation.

Preconditions: ***IMPORTANT: Before the measuring station is started, the correct installation of the measuring station must be checked.***

WARNING

Laser light sources class 3 may cause blindness & visual impairment, work on laser components during operation of the instrument is not permitted!

- *Switch on the device fuse / fault current circuit breaker (designator 1) inside the weather protection housing. SwisensPoleno starts automatically.*



- *Wait until the integrated computer is fully booted and the desktop of the operating system appears on the monitor (if necessary, the monitor must be switched on).*
- *Check the two push buttons in the front door of the unit. Both push buttons should light green. A flashing upper push button indicates the detection of a particle.*
- *Fold up the keyboard shelf and snap into place*

  IMPORTANT: Make sure that the tray is correctly engaged. A sudden fall may result in damage and/or accidents.

- *Perform connection check to swisensdata server via terminal*
  - *Open terminal with right mouse click on desktop (Open Terminal)*
  - *run ping swisensdata.ch and check output*

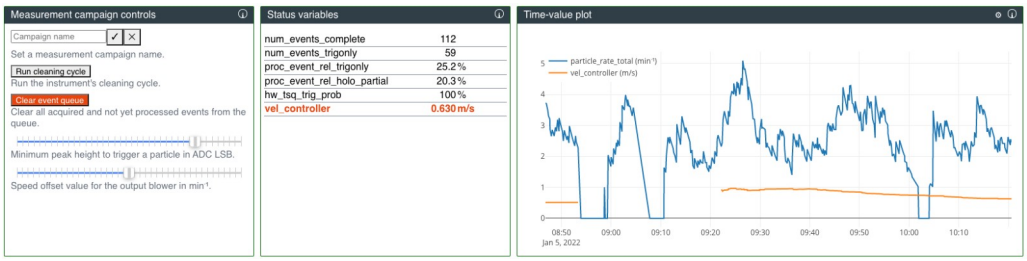
IMPORTANT: Internet access is recommended (at least outgoing port 1195) to

enable remote monitoring and support through Swisens

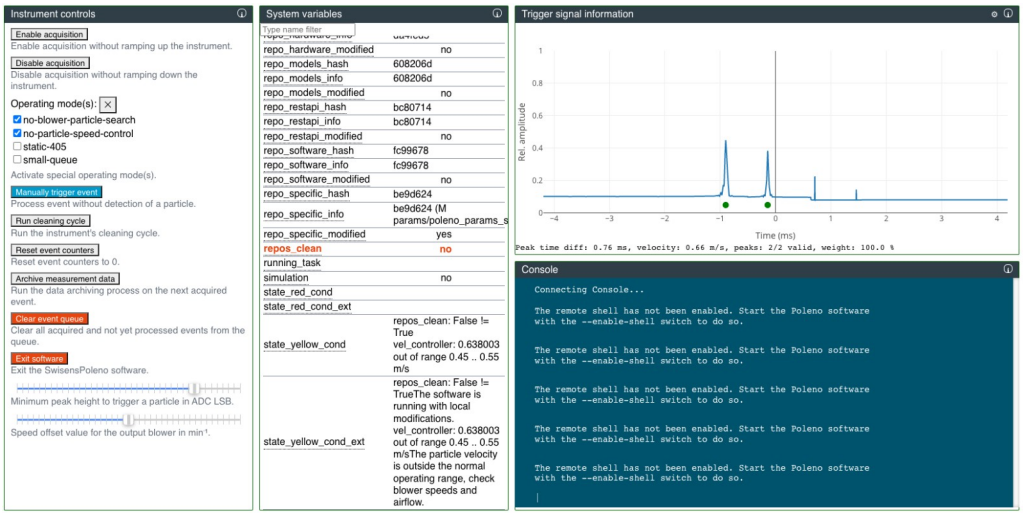
- *Check if the docker containers are running (terminal):*
  - *Terminal: ~/repos/poleno-software/swisenspoleno_docker.sh up or Shortcut "Start SwisensPoleno" on Desktop*
- *Launch SwisensPoleno Cockpit*
  - *Browser (https://localhost:4987) or Shortcut "SwisensPoleno Cockpit" on Desktop*
  - *Check particle velocity (Velocity)*

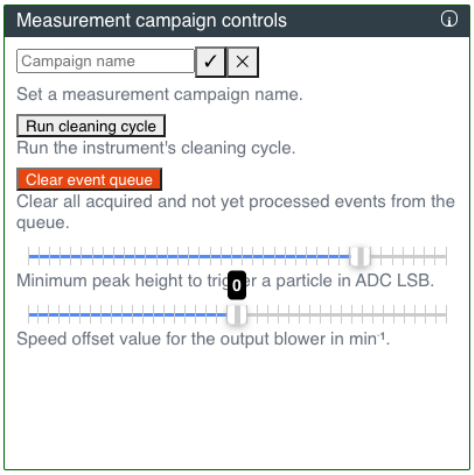
Note: Typically, a few particles per minute should always be detected. The particle velocity should be approx. 0.5m/s (±0.05)

- *Function tests:*
  - *Each time the system is moved to a new place it is recommended to perform some basic tests to ensure proper operation*
  - *Depending on the air resistance at the input and output of the system, the speed of the output blower has to be adjusted to meet the proper working point*
- *Adjusting blower speed*
  - *Either have the Sigma-Inlet or an active Swisens Atomizer mounted at the inlet of the system*
  - *If necessary reduce Minimum peak height to allow also smaller particles to be detected*
    - *navigate: sidebar → measurement campaign → measurement campaign controls → move slider "Minimum peak height to trigger a particle in ADC LSB"*



  - *Disable «Particle speed control» option (navigate: sidebar → status and control → Instrument controls → activate options "no-blower-particle-search" and "no-particle-speed-control")*



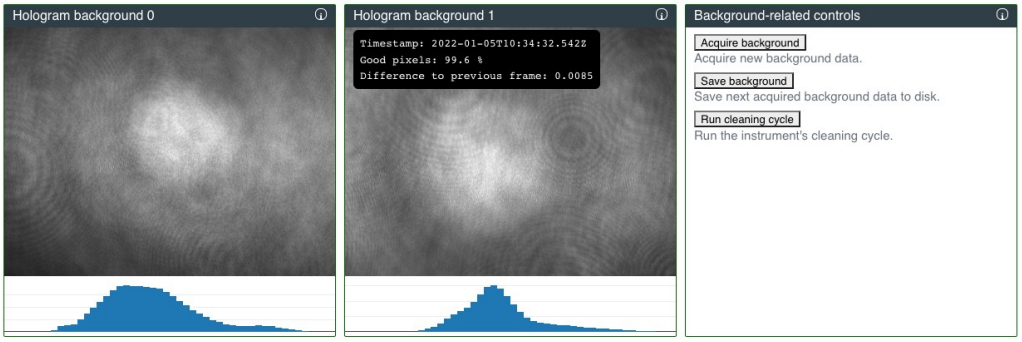


- *Increase speed of output blower until particles are detected (navigate: sidebar → measurement campaign → measurement campaign controls → move slider "Speed offset value for the output blower in min⁻¹")*
- *Change «Speed offset value for the output blower in min⁻¹» until particles are detected at a speed of ~0.5m/s (check variable "vel_controller" under status variables)*
- *Open parameter file ~/repos/poleno-specific/params/poleno_params_specific.py*
- *Adjust property «hw_out_blower_speed_bias» to the acutal output blower speed (rounded to 100 and add 200) which is visible in the cockpit*
- *Restart docker containers*
- *Particle velocity will automatically be regulated to 0.5m/s*

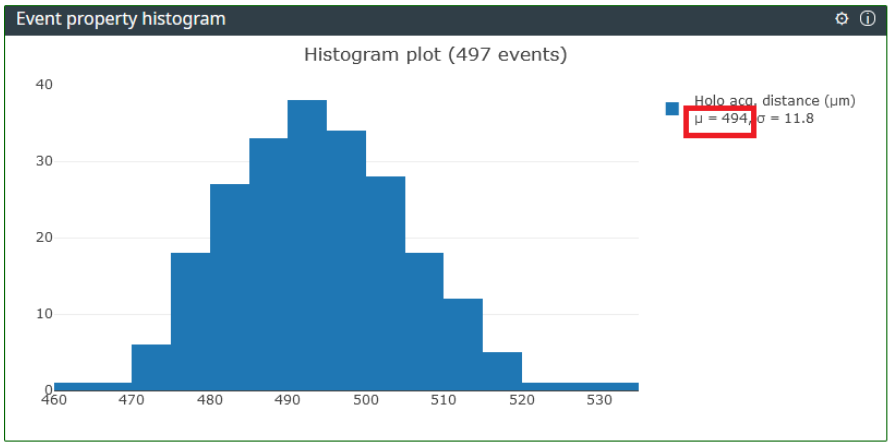
- *Check flow-rates and fan speeds*
  - *Make sure the system is running and in FSM state «MEASURING» (check status overview "fms_state")*
  - *navigate: sidebar → status variables → Status variable group 2*
    - *Output airflow (hw_out_flow): 40±4 l/min*
    - *Bypass airflow (hw_byp_flow): 35±3 l/min*
    - *Measurement chamber airflow (meas_flow): 5±2 l/min*
    - *Concentrator airflow (hw_con_flow): 65±10l/min*

- *Output blower speed (fan_output_rpm): 8500±2000 rpm*
- *Concentrator blower speed (fan_concentrator_rpm): 20000±4000 rpm*

- *Check background images*
  - *Make sure the system is running and in FSM state «MEASURING» (check status overview “fms_state”)*
  - *navigate: sidebar: background data → Acquire background*
    - *hover over picture → “good pixels” value should be over 95%*



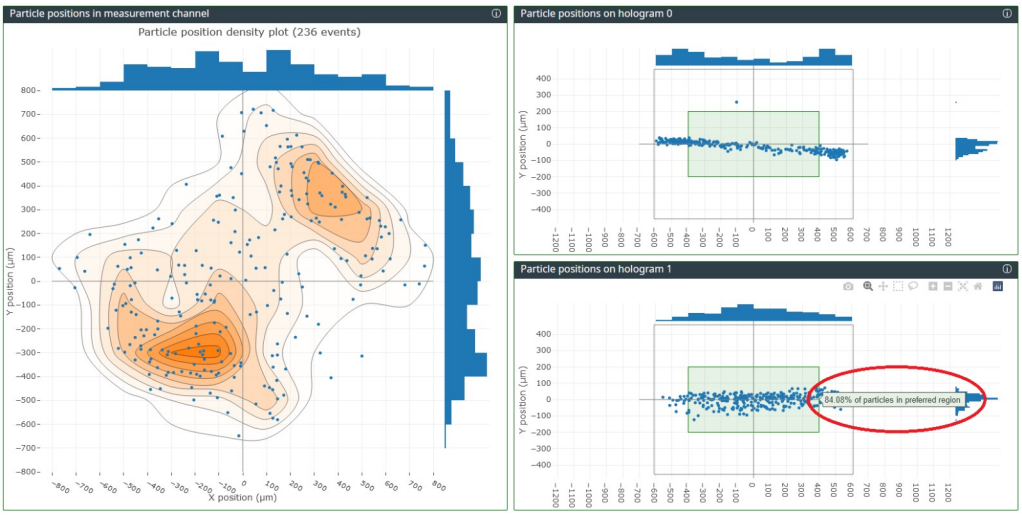
- *Check particle velocity and holo distance*
  - *Make sure the system is running and in FSM state «MEASURING» (check status overview “fms_state”) and particles are detected*
  - *navigate: sidebar → status variables → Status variable group 2*
    - *Check Particle velocity (vel_controller): 0.5±0.05 m/s*
  - *navigate: sidebar → event information → Event property histogram*
    - *hover over settings (top right) and activate only “Holo acq. distance (µm)“*
    - *Check Vertical distance of the particles in the two holography images: 500±50 µm (Mean Value of the histogramm)*



- *Check particle beam quality*

  For the measurement of parameters like particle beam quality or holographic images, lycopodium spores or PSL-spheres with a defined diameter (for example 20 µm) and density (for example 1050kg/m^3) can be used. They can be dispersed into the air by SwisensAtomizer.

  - *Make sure the system is running and in FSM state «MEASURING» (check status overview "fms_state") and particles are detected*
  - *Preferrably monodisperse particles > 10 µm are disperged and measured with Swisens Atomizer*
  - *navigate: sidebar → particle positions*
    - *check particle positions in "Particle positions on hologram 0" and "Particle positions on hologram 1" by hoovering over the area highlighted in green: At least 70% of all particles should be within the preferred region of ±400 µm, measured from the center of the camera image*



- *Check quality of holographic images*
  - *navigate: sidebar → overview*

- *Random qualitative control of the reconstructed images (Reconstructed holographic image 0 & Reconstructed holographic image 1) with regard to sharpness (by comparison with reference images).*
- *The size of 80% of the evaluated reconstructed images must be 20µm±2 µm (if 20 µm PSL-spheres are used, see above).*

- *Add location information:*
  - *Open parameter file ~/repos/poleno-specific/params/poleno_params_specific.py*
  - *Adjust properties «gen_system_location_lat_lon» and «gen_system_location_address» according to the description in the parameter file*
  - *Restart docker containers*

- *If problems occur during commissioning, the following tests must be carried out (not conclusive)*
  - *With a 4G connection: Call up the configuration page of the mobile router using a web browser (http://192.168.2.1/) and, in particular, check the gateway/mobile settings.*
  - *For Ethernet connection: Check local network connection, contact local administrator if necessary.*
  - *Assembly of a SwisensAtomizer at the Sigma-Inlet and atomization of reference particles (e.g. PSL Spheres or lycopodium spores)*
  - *Vary output airflow via SwisensPoleno Cockpit until particle velocity is approximately ~0.5m/s.*
  - *Activation of the cleaning cycle via SwisensPoleno Cockpit (navigate: sidebar → measurement campaign → "run cleaning cycle") to remove any blockages.*

    → If the problems cannot be resolved, contact support.

- *If there are no problems, the system is ready for operation. Fold in the keyboard and close the maintenance door.*

IMPORTANT: Risk of jamming when folding in the tray.

IMPORTANT: The maintenance door must be fully engaged in the lock so that the key can be removed. After removing the key, check that the door is locked.

4.2. Operation

4.2.1. Operational monitoring

All operating parameters of a SwisensPoleno measurement instrument are stored in the local database and, if configured accordingly, replicated on a server. Using the REST API, all logged data can be retrieved at any time locally on the corresponding instrument or on the server, e.g. using the Swisens System Monitor.

Access to the operating parameters via the REST API enables monitoring by cyclically checking the operating parameters for defined value ranges. Relevant operating parameters are particle velocity, particle concentration, suction volume, temperature, response time and storage space allocation (not exhaustive). If a rule is violated, a pre-defined action can be triggered (e.g. sending an e-mail to the administrator) so that measures can be taken to remedy operational faults.

To make the system redundant, the same software can run on a separate system and access the REST API externally. This also allows error cases to be detected on the server.

Alternatively, server monitoring can also be performed using an existing solution or an external tool. Possible monitoring solutions are Nagios[1], Zabbix[2] and OpenNMS[3].

The monitoring solution only needs to be able to query JSON data via a REST API, interpret the values contained therein and generate corresponding events.

The monitoring solution can also be used directly on the measuring instrument itself and access the local database via the REST API. It should be noted that not all errors of the measuring instrument can be detected (e.g. connection interruption), as the monitoring software may also be affected.

4.2.2. Operating overview

With the Swisens System Monitor, the current status of the system can be viewed. The history of the operating parameters of all measuring instrument connected to the server can be displayed in graphs. Information on the current replication process is also displayed. The Swisens System Monitor is the first point of contact for an administrator to gain an overview if an irregularity is detected.

In addition to the Swisens System Monitor, the current status can also be monitored directly on the measuring instrument using the SwisensPoleno frontend interface. In addition to displaying the current operating parameters, it is also possible to adjust individual parameters during operation.

1 https://www.nagios.com
2 https://www.zabbix.com/
3 https://www.opennms.com/

4.2.3. Functionality test

A functionality check can mainly be done by a visual comparison of the reconstructed images with the corresponding classification. In most cases a trained person can judge relatively well whether the particle depicted on the images has been assigned to the correct particle class or pollen class.

In addition, the trigger photodiode signals and operating parameters such as particle airspeed, flow rate, fan speed, etc. can be controlled. However, expert knowledge is required to interpret these parameters. The operating parameters are described in the documentation of the REST API.

4.3. Training data set generation for new particles

The detailed description of the training data generation process is described in the separate "Training Data Generation Guide".

4.4. Maintenance work

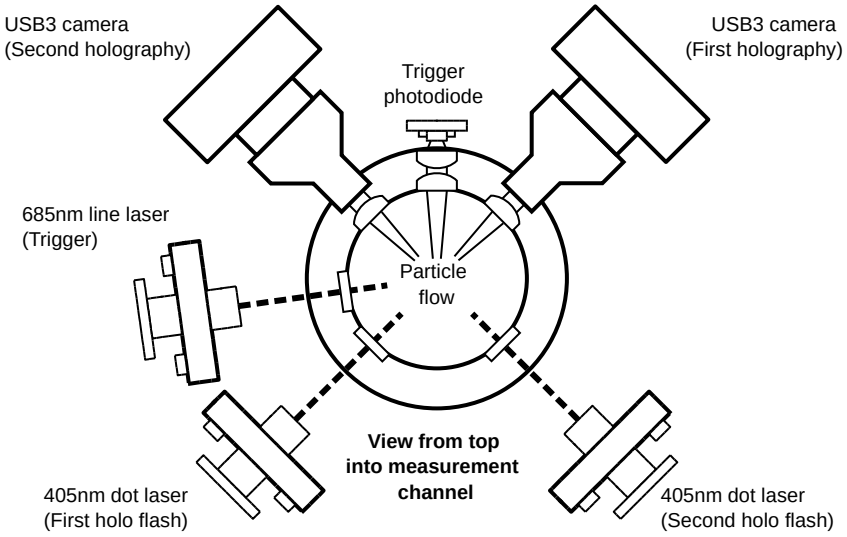
The detailed description of the maintenance work is described in the separate "Maintenance manual".

5. Function principle

5.1. Identification characteristics

SwisensPoleno works on the basis of the optical identification of individual particles in an air stream that passes through the instrument. An inlet with Sigma 2 geometry above the weatherproof housing allows the ambient air to enter a vertical tube through the roof of the weatherproof housing and into the measuring instrument. There the main part of the aspirated air is diverted by means of virtual impaction without deflecting the larger particles contained in it. This takes place in three stages, so that when entering the measuring channel a fine air stream acts as a carrier for the particles, which is surrounded by a largely clean sheath flow.

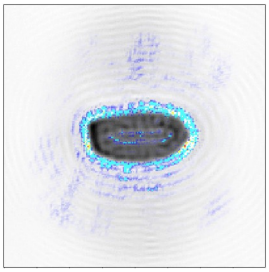
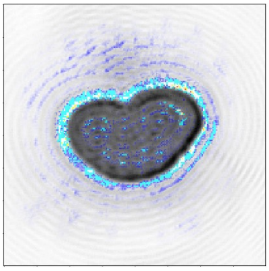
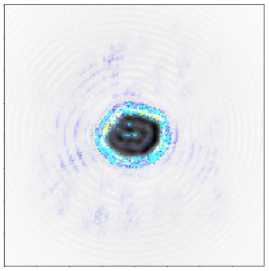
Within the measurement channel, a collimated laser beam is first directed across the channel, which is slightly scattered by particles in the centre of the channel. This scattered light is detected by a photodiode and triggers a detection event when a configurable threshold is exceeded.



After the triggering of a particle, it is illuminated after the corresponding time delay by two laser pulses. These serve as exposure for two camera sensors, which are mounted on the other side of the measuring channel directly opposite the corresponding laser source. This setup corresponds to digital inline holography[4], because the coherent light of the laser is diffracted by the small dimensions of the particle. The images are transferred to the integrated computer and refocused at the appropriate object distance.

The refocused images are evaluated by the identification algorithms and the results are used to classify the particle. The following images show some examples of refocused images with superimposed heat maps. The heat maps show which features within the image have contributed to the classification and to what extent.

4 Latychevskaia, T., & Fink, H.-W. (2015). Practical algorithms for simulation and reconstruction of digital in-line holograms. Applied Optics, 54, 2424–2434. https://doi.org/10.1364/AO.54.002424

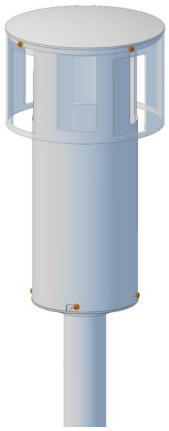
Pollen-species	Quercus Robur	Pinus Strobus	Betula Pendula
Image with heatmap			

Each detected particle is recorded as an independent event and stored in a local database. These events are available with all associated measurement data and the classification based on them for further processing by the customer.

5.2. Intake pipe

The SwisensPoleno measurement instrument is mounted for outdoor use in a weatherproof housing, which is equipped with an inlet pipe vertically upwards. The end of the pipe is a hood with Sigma 2 geometry (VDI 2119 Ambient air measurements – Sampling of atmospheric particles larger 2.5µm). This construction offers protection against environmental influences such as rain, snow, solar radiation, etc. and protects the measuring instrument against the penetration of larger foreign bodies (especially insects) thanks to the additional fine-meshed grids attached to the inner four inlets (mesh size 1 mm).

IMPORTANT: The inlet geometry also serves as a beam trap for the laser, which is directed vertically upwards through the entire instrument. Operation without a Sigma 2 inlet therefore represents a safety risk and is not permitted!



The airflow is set by SwisensPoleno to a nominal 40 l/min (2'400 litres per hour) with an integrated blower and a flow sensor. During operation, this operating point can additionally shift in the range of ±10%, so that the velocity of the measured particles remains at the target value of 0.5m/s despite changes in air temperature and humidity.

5.3. Availability of result data

During operation, SwisensPoleno continuously aspirates air from the environment and detects particles passing through the instrument. For each event, the measuring subsystems are activated in staggered order and record data as the particle moves through the measuring channel. The recorded data is then transferred to the integrated computer within a few milliseconds and evaluated there. The evaluation typically takes 0.3s to 1s (several events can be evaluated in parallel) until the data is available in the integrated database. From this point on, they can be retrieved via the instruments's REST API and/or synchronized to an external data server. The time required for this process depends primarily on the speed and stability of the data connection to the data server. It can be expected that the data of an event can be retrieved from the external data server within less than 1 minute. With a fast network connection, the delay is typically less than 10s.

5.4. User-friendly interfaces

The Poleno measuring instruments store their measurement data (raw data and results of the evaluation) in local MySQL databases. The database content can be automatically synchronized to an external data server by means of binary log files[5]. An interface for structured access to the data in the database is available both on the measuring instruments and on a data server from the Swisens Ecosystem. This is based on REST[6] and is therefore called REST API (representational state transfer application programming interface). Thanks to the underlying HTTP of this REST implementation, the interface can be used with a web browser, or programmatically addressed from a script/program. All required program libraries are open source and freely available. A description of the endpoints of the REST API can be found in the Swisens Data REST API documentation.

It is also possible to directly access the MySQL database and retrieve the data in this way using custom queries. Please contact Swisens for further information if this is desired.

For interactive access to the data, browser-based programs (SwisensDataExplorer, Swisens Data Analyzer) are available, which prepare and format the measured data. This means that individual events (measured individual particles) can be output with recorded images and identification results or time series of the particle concentration. These programs are completely executed in modern web browsers and use the REST API of the measuring instruments or the data server. They are platform independent and do not require any installation. On the instrument itself the data can be accessed via http://localhost:8081. A description of the software can be found in chapter 3.5

The reconstructed images allow a visual comparison and a simple functionality check.

Thus the data is available in three different abstraction levels: Directly from the SQL database using SQL queries, via the Swisens REST API and via a graphical web interface.

The SwisensPoleno frontend interface is also available for setting and diagnostic work on the instrument, which can be used via control elements (keyboard, mouse, monitor) when connected to the weatherproof housing or over the network via VNC (virtual network computing). The operat-

5 https://dev.mysql.com/doc/refman/8.0/en/replication-options-binary-log.html
6 https://restfulapi.net/

ing parameters, which can be viewed via this graphical user interface, can be used for functionality testing.

All mentioned interfaces are based on open protocols/technologies and have been developed in cooperation with customers especially with regard to their user-friendliness.

5.5. Monitoring of operating status

The instrument periodically records operating parameters, which can be retrieved from the MySQL database via REST API in the same way as the measurement data. The corresponding endpoints of the REST API and the available parameters are described in the Swisens Data REST API documentation.

The recording intervals differ from parameter to parameter and depend partly on the values in order to detect conspicuous changes without generating an enormous flood of data. The recording intervals are configurable for most parameters. In addition to access via REST API, it is also possible to view the data from the local log file of each instrument in the directory "/home/swisens/meas_data/logs/".

5.6. Autonomy of the system

The SwisensPoleno software runs inside docker containers[7] (a lightweight alternative to virtual machines), which run automatically when the system starts. The hardware is fully automated initialized and operated; simple errors are automatically fixed.

The measurement results are stored locally and automatically transferred to an external data server, provided that a data connection is available. Otherwise, the data will be transferred to the server at a later time as soon as a connection is established. The system is therefore offline capable and can function fully for a certain time without a network connection. The only limitation is the available storage space for the measured data. For security reasons, the use of a VPN solution is highly recommended for the connection to the server; the components of the "Swisens Ecosystem" use the open source OpenVPN software for this purpose.

The operating system of the instrument may be kept up to date by automatically applied security updates, provided that access to a corresponding mirror server with the necessary packages of the Ubuntu operating system is available. Otherwise, the updates should be installed manually on a regular basis.

5.7. Software updates

The entire application-specific software including the operating parameters of the Poleno measuring system is stored in software repositories, which are managed with the freely available tool Git[8]. The repositories are synchronized to the local computer of the instrument and stored in the directory "/home/swisens/repos/". The main software is distributed in three repositories:

- poleno-software: Actual software code (mainly Python) which is executed on the instrument computer. This data is identical for all SwisensPoleno instruments.

- poleno-ml-models: The machine learning models which are applied to the measured data using TensorFlow[9]. It includes the currently available models, from which one or multiple is/are selected in poleno-specific. This data is identical for all SwisensPoleno instruments.

- poleno-specific: Instrument-specific data and parameters, including the firmware image for the hardware used. Each instrument has its own such repository on the Swisens server, which contains the specific parameters. This means that differences between instruments as well as parameters adapted later can be traced at any time. Mainly this includes the file params/poleno_params_specific.py, which contains the system parameters as a Python class.

In addition to the listed core repositories, there may be several other repositories checked out for supplementary functions. Depending on how an instrument is actually used, not all of those may actually be present:

7 https://www.docker.com/
8 https://git-scm.com/
9 https://www.tensorflow.org/

- autocleanup: Scripts to automatically move/delete local measurement data to free up space on the internal SSD. The cleanup.py script may be modified to fine-tune the behaviour. It is usually run via a cron job.

- poleno-restapi: The implementation of the local REST-API and SwisensDataExplorer.

- poleno-router-status: For instruments using the integrated mobile router, the integrated script can be used to periodically log mobile connection information. This data may later be used to debug connection interruptions.

- tiva_ethloader: The bootloader frontend used to update the firmware on the SwisensPoleno hardware unit.

Updates for the repositories can be downloaded from the Swisens server (if a connection exists) or imported using file archives/patches. The commit messages of the repositories serve as change logs, which can be retrieved from the repositories at any time using Git. Additionally, the main software repository poleno-software also contains a CHANGELOG file, which summarizes the implemented changes. Git diff can be used to see those summaries between two repository versions.

The customer is free to make changes to the software of the instrument himself. Swisens strongly recommends using the existing infrastructure of the Git repositories so that further updates can be efficiently and securely maintained by the manufacturer. Swisens is interested in working in partnership with the customer, so it is desirable but not mandatory for improvements made by the customer to be made available to the manufacturer for transfer to the central repositories. Should the customer's equipment fail as a result of his modifications, Swisens may charge for the cost of solving the problem, unless other agreements are in force. This also applies if changes cause problems/conflicts with future software updates on the part of the manufacturer.

5.8. Software source code

The recognition software source code is locally available on the instrument and accessible via the software repositories in /home/swisens/repos.

6. Technical documentation

6.1. Accessories

The following accessories usually are supplied with a system.

Accessory	Usage
Compressed air spray	For cleaning purposes
WLAN-Stick	Connectivity
Lycopodium / Baerlapp Spores	For testing purposes
Mesh wire	Spare part for sigma-inlet
Grounding clamp	Lightning protection
6mm copper wire	Connecting grounding clamp to lightning arrestor

6.2. Spare parts list

Spare part	Manufacturer	Manufacturer's designation
Measurement instrument	Swisens AG	SwisensPoleno Mars
Sigma-2 Air Inlet	Swisens AG	Sigma-2 Air Inlet
KABA 5000 key	KABA	KABA 5000