# CortiView 2

fNIRS signal acquisition software

Instruction Manual

(version 1.1.0)

CORTIVISION

**Cortivision sp. z o.o.**
ul. Tomasza Zana 11a
20-601 Lublin, Poland
support@cortivision.com
www.cortivision.com

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# Recent release notes

**1.1.0**

**Software:**

- Tandem mode (dual amplifier, 4-bundle) support
- Advanced 3D montage creator for DOT measurements
- Increased number of available time-slots from 24 to 32
- Concept of medium channels introduced. This can further increase the dynamic range of the system
- Added firewall exception and faster startup time
- Calibration abort feature
- Ability to stream HbO and HbR values via LSL stream introduced
- Fixed a bug in the DOT multiplexing matrix calculation

**Firmware:**

- More reliable wireless connectivity
- Tandem-related changes
- Enhanced LED status (incorrect bundle connection, CortiView2 not running)
- Auto switch off when idle for 15 minutes
- Fixed an extensive battery drain when the device is switched off

**1.0.3**

- Dual-timeslot Diffuse Optical Tomography (DOT) measurements feature
- Import of High-Density (HD) custom-designed montages from AtlasViewer
- Scalp Coupling Index calculation and display during calibration and in the Scroll Chart Plot window
- Predefined brain orientations in the 3D view tab
- Better handling of missing samples
- Channel selector
- Better remote logging
- More responsive GUI, ability to display 150+ channels
- Fixes for reported bugs

**1.0.2**

- Critical fix for bug introduced in v1.0.1 for single bundle devices
- Data path checks before recording
- Ability to choose the number of available bundles in the montage creator

**1.0.1**

- Bugfix for end recording when using API
- Ability to put markers from the keyboard
- Swapped bundle connection check and warnings
- Device info window with extended device, bundle, and device battery properties
- Batch SNIRF file recovery from SD
- Input LSL marker stream monitor on the status bar
- SNIRF converter 4x speed increase
- The instruction manual is available from the menu item inside the app

**1.0.0:**

- first complete release of the application.

# Introduction

## About the program

CortiView 2 software allows you to view and record the level of brain oxygenation in the near-infrared recorded with the Cortivision SPECTRUM C23 fNIRS device.

## System requirements

The software is compatible with the following operating systems: Windows 10/11

| | MINIMAL | RECOMMENDED |
|---|---|---|
| CPU | Dual Core | Intel Core i5 |
| Memory | 4 GB RAM | 8 GB RAM |
| Graphics card | Integrated 128 MB | Integrated 256 MB |
| Disk space | 1 GB of free space | 5 GB of free space |
| Resolution | 1920x1080 (scale 125%) | 2560x1600 (scale 150%) |

# How to configure devices

## WiFi router

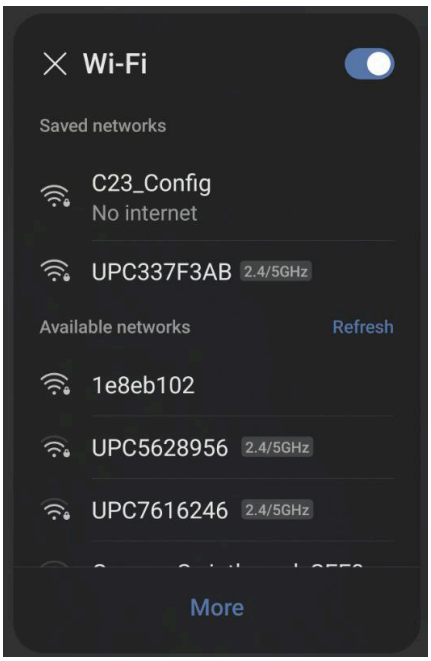
1. Turn on the provided WiFi router (stationary or portable) as part of the set according to the user manual.

2. Check the network name (SSID) and password. If necessary, modify them as needed.

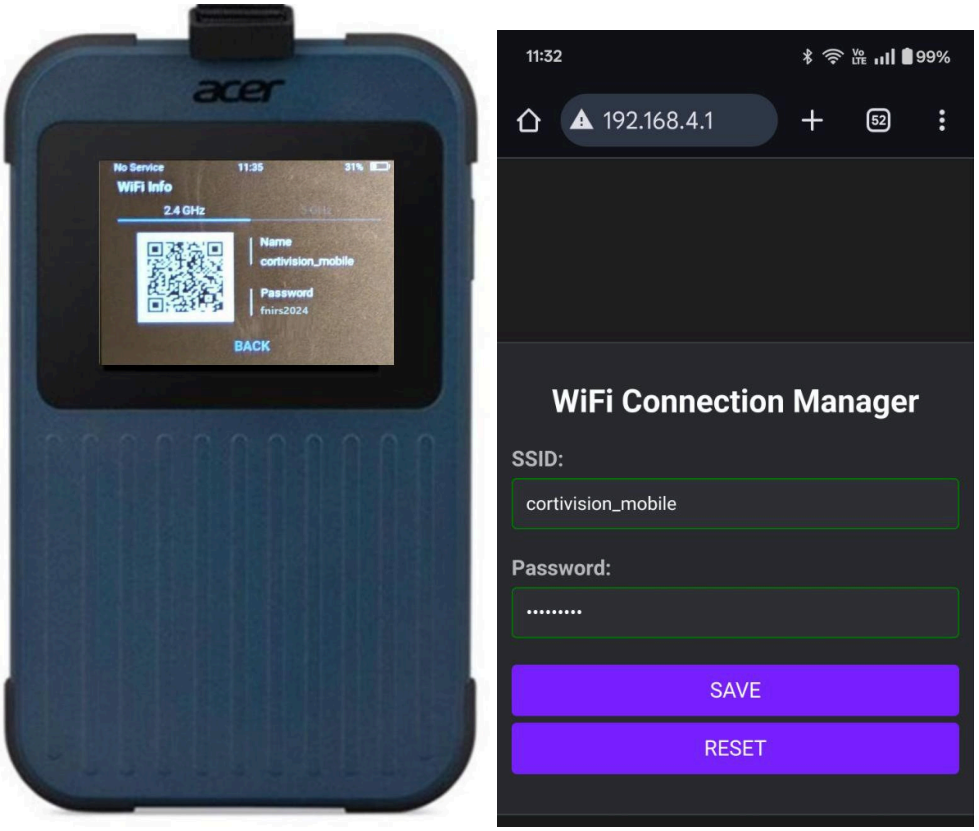
## Amplifier

1. Switch on the amplifier by holding the power button for 3-5 seconds. Then press the button for 3-5 seconds until the LED changes colour from **yellow** to **violet**. The device will switch to Access point mode, creating its own Wi-Fi network named ‘C23_Config’.

2. Using a smartphone or laptop, find the ‘C23_Config’ network and connect to it. You may have to enter the password. Use **12345678.**




3. Open your Internet browser and enter the amplifier IP address: **192.168.4.1**
4. Type your WiFi network name (SSID) and password. **Note: The network name and password must be the same as those for the WiFi router.**




5. Then, accept by clicking on the save and restart buttons. The device will automatically restart, and all LEDs will go out. After the restart LED will turn **violet** to **yellow**. Within a few seconds, it should change the color to **green**. Your device is connected to Wi-Fi correctly if LED is lights **violet**.

## Data acquisition laptop

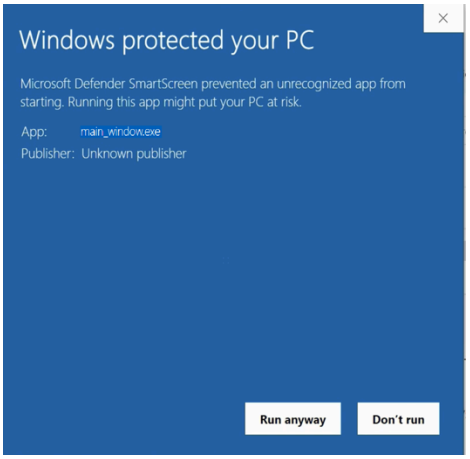
1. Connect to the same network as the amplifier.
2. Install and open the CortiView 2 application according to the instructions described in the next section.

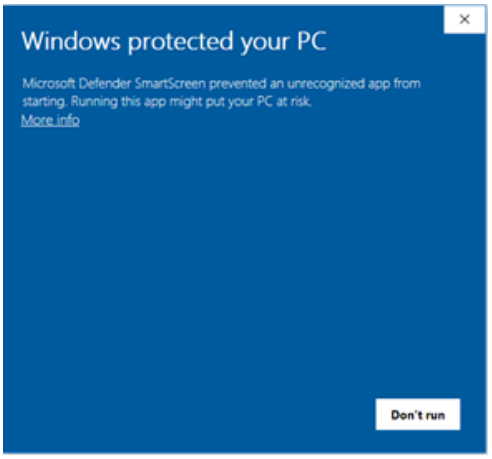
# Installation

The CortiView 2 application is distributed as an .exe file.

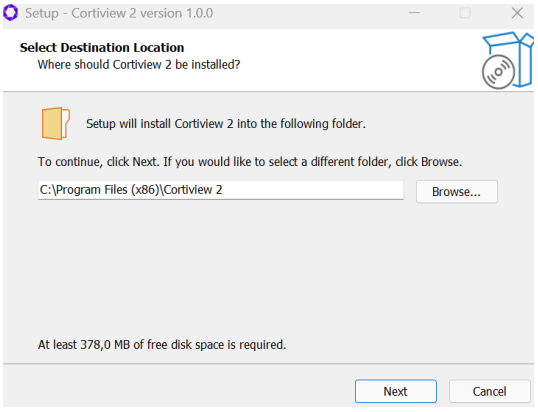
To install the application for the first time, you need to:

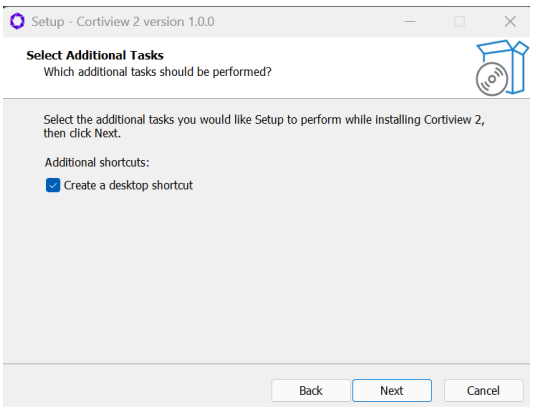
1. Double-click on the cortiview.exe
2. You can see the Microsoft Defender SmartScreen window. First, click “more info”.




3. And then click “Run anyway”.
4. You will be asked to select the folder for installation and whether a shortcut to the program should be created on the desktop.



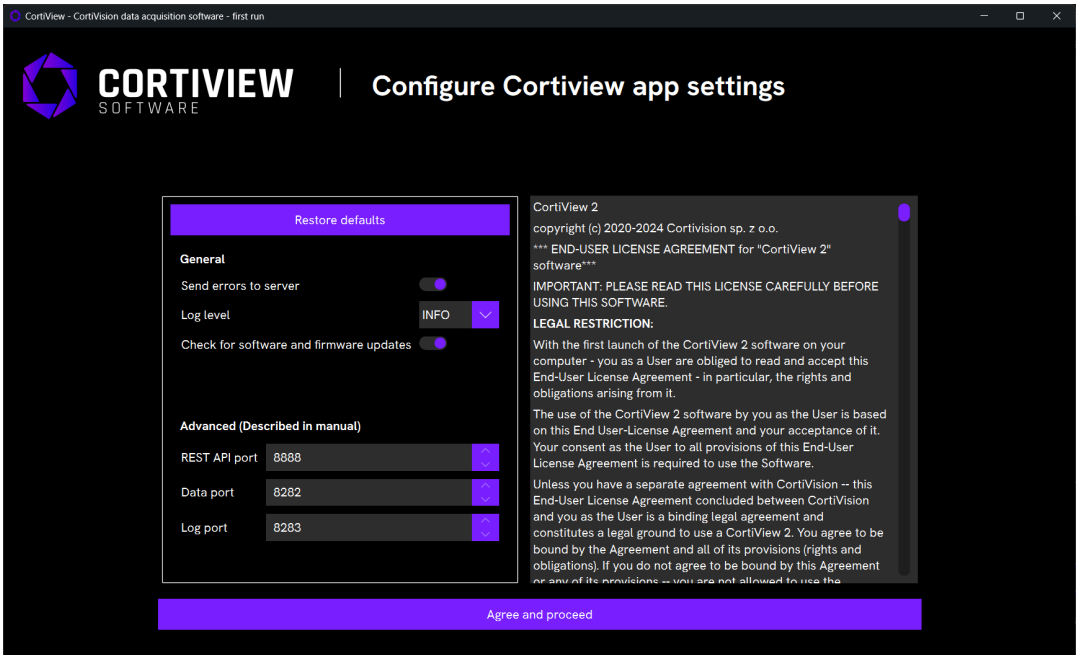

5. After installation, all configuration files and logs are stored in the user's home directory in the ‘cortiview 2’ subdirectory. This location is also a default location for storing the recordings in SNIRF format.

# Start-up

## First-time startup

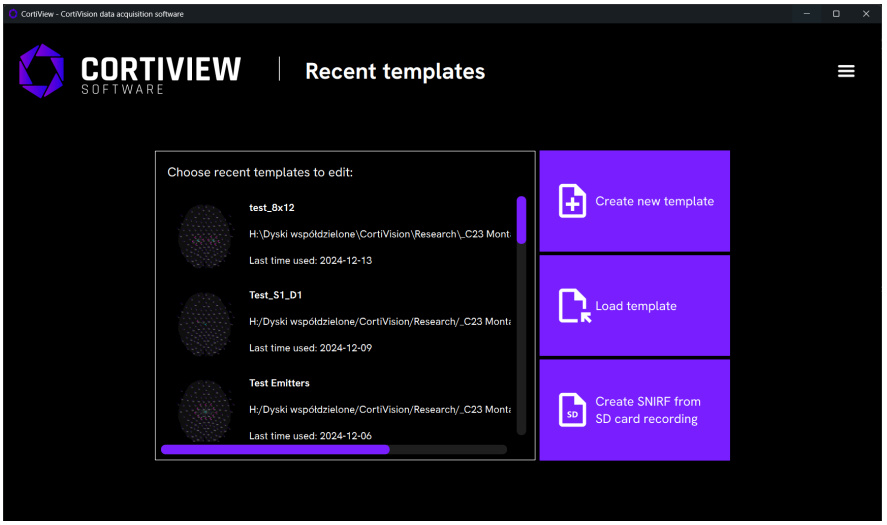
When you run CortiView 2 for the first time, you will be asked to read and accept the terms and conditions of the license and configure the main parameters of the application:

- Send errors to server - allows enabling or disabling reporting errors to the Cortivision server. **Note:** We encourage you to make this option available for faster diagnostics of problems where support is needed. You need to have an Internet connection for this function to work properly.
- Log level - Choose what events will be recorded in the log file. Increasing the log level from INFO to DEBUG will increase the amount of data written to the log file. Decreasing the log level from INFO will result in lowering the amount of data written to logs but could result in a reduced ability to identify system problems.
- Check for software and firmware updates - Allows enabling or disabling online update check. The software will notify the user if the update is available. You need to have an Internet connection for this function to work properly.
- REST API port - Send API commands to this port. Change this if another software occupies the port, e.g., the Jupyter Notebook has **port 8888** as a default value. Thus, it will prevent the use of REST API in CortiView2.
- Data port - The port number where data from the device will be sent. Change this only if another system already occupies the port number. Changing the port number in the software requires the corresponding change in the device settings. Put the device into network configuration mode, connect to the **C23_config** Wi-Fi network, and type **192.168.4.1/advanced** in your browser and change the port number.
- Log port - The port number where logs from the device will be sent. Change this only if another system already occupies the port number. Changing the port number in the software requires the corresponding change in the device settings. Put the device into network configuration mode, connect to the **C23_config** Wi-Fi network, type **192.168.4.1/advanced** in your browser, and change the port number



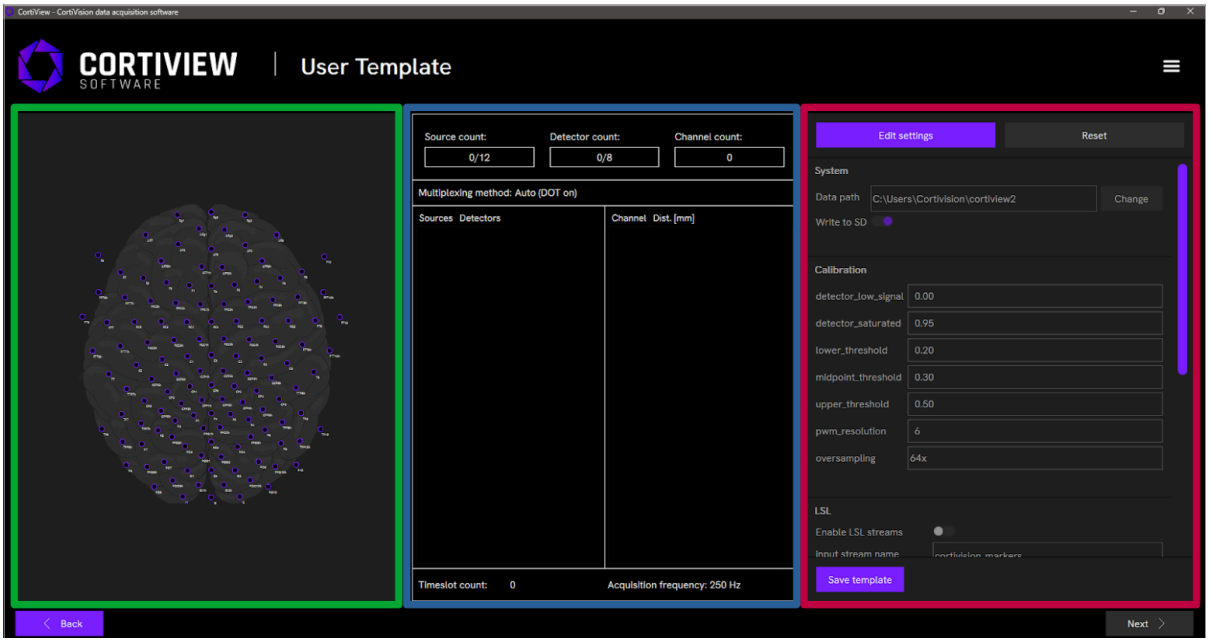

## Run CortiView 2

The first window after launching the application will contain recently used recording templates containing acquisition parameters. The previously saved file can also be opened by clicking the Load template button.




If the application has not been used before, the list of templates will be empty. Select the 'Create a new template' button to set the first recording configuration.

# User templates




On the screen with the user template configuration, the user can:

1. Define template settings
2. Create, edit, or load montage
3. See the template summary

## Template settings

Settings can be set by clicking on the Edit settings button.

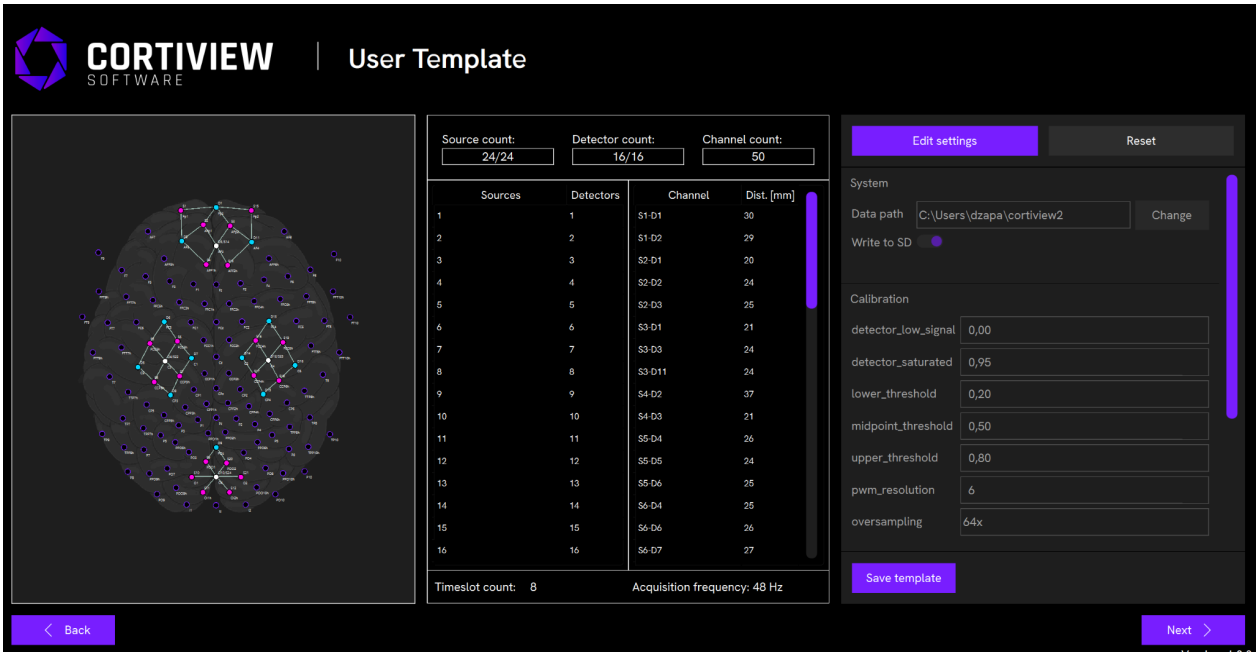
- System - allows changing the data recording path and enabling or disabling signal recording on the memory card.
- Calibration - includes a list of advanced settings for detector and emitter calibration procedures.
- LSL - allows enabling or disabling the Lab Streaming Layer (LSL) function and renaming specific LSL streams. You can enable or disable streaming of raw intensities as well as hemoglobin concentration values[1].
- Scalp coupling index (SCI) - allows display of SCI values in measurements and change of thresholds of this signal quality indicator.

You can save the configured template parameters by clicking the Save template button in the template main window. To go straight to signal acquisition, press the Next button.

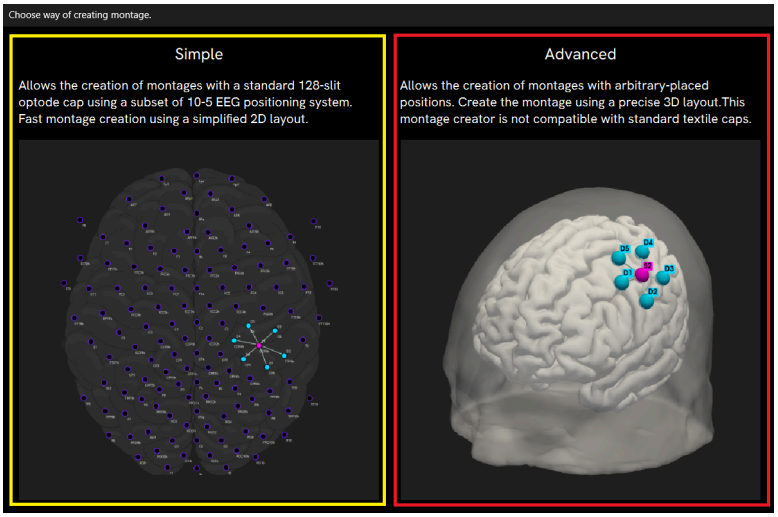
[1] Using LSL stream with hemoglobin concentration values requires careful consideration of the use of Baseline button. When Baseline button is clicked, a relative hemoglobin concentration values will be reset to zero. If this LSL data stream is used for realtime data processing, use Baseline button with caution.

# Montage

You can edit, create, or load a montage by clicking on the optodes location visualization (left panel).

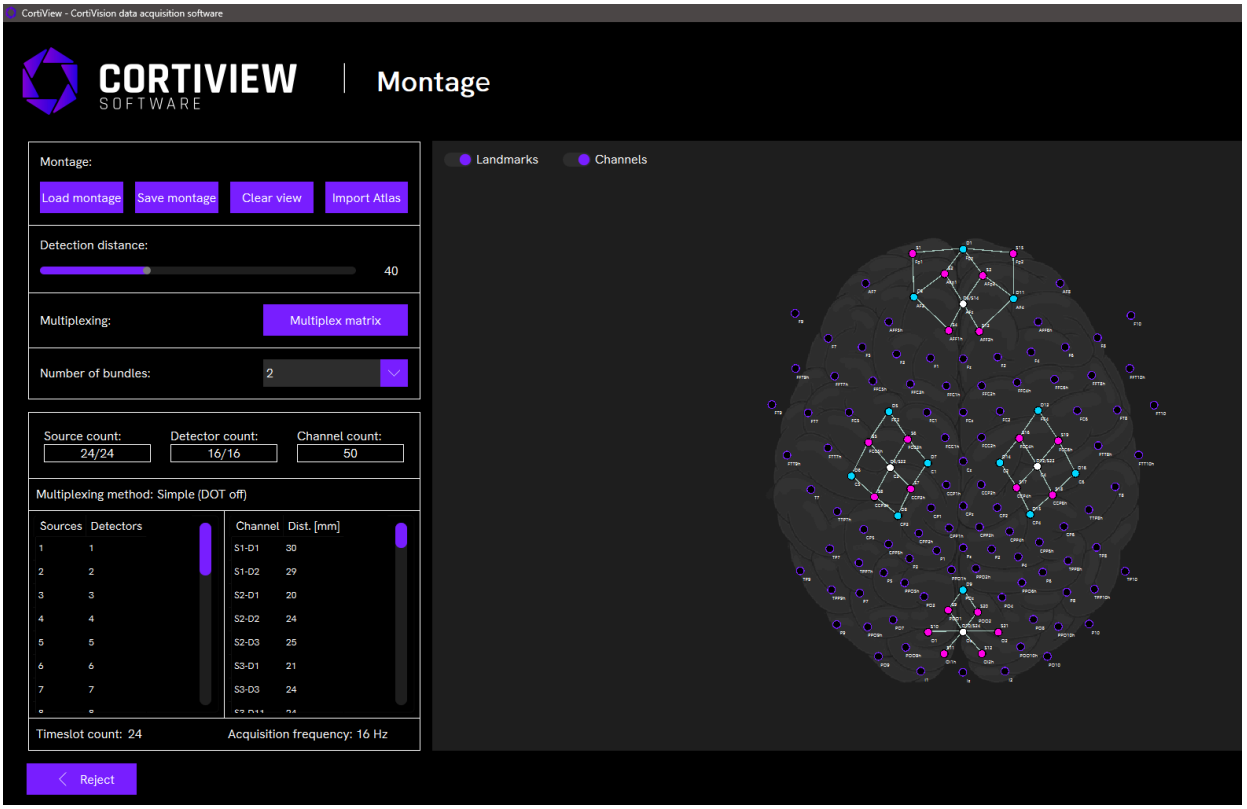



Once clicked, a new pop-up window will appear asking to choose either a **Simple** or **Advanced** montage creator.



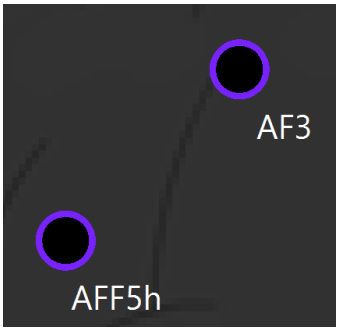
## Simple Montage Creator

In a simple montage creator window, the user can configure the registration parameters (left panel) and the positions of emitters and detectors on the '10-5 system' cap (right panel).

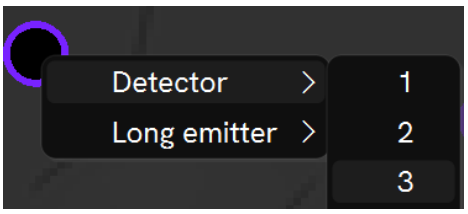



- Montage - allows loading previously saved emitter and detector positions ('Load montage'), saving created or modified positions ('Save montage'), clearing the right panel view ('Clear view'), or importing high-density custom montages from AtlasViewer ('Import Atlas')

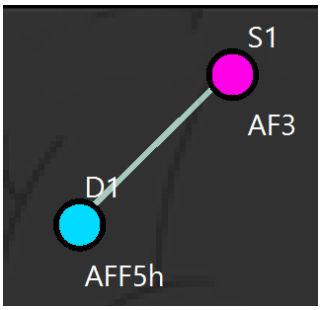
  The optode position can be defined by left-clicking on each point on the right panel. Right mouse click deletes the previously defined optode.



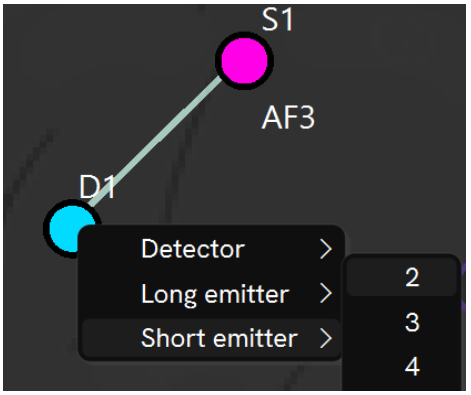

  Then, from the open menu, you can choose between the detector, the emitter, and its number.



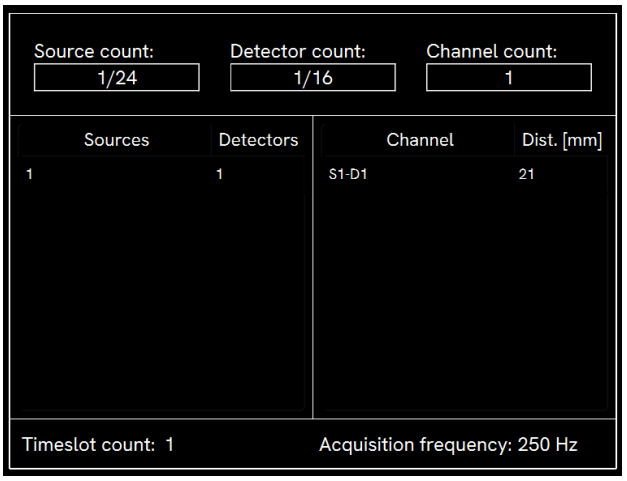

A measurement channel will be automatically created if the emitter and detector are within the distance defined in the 'Detection distance' panel.




To create a short channel, left-click on a previously defined detector and select the correct emitter number.




The table at the bottom of the left panel summarizes the choices, showing the number of emitters, detectors, and channels created. In addition, information on the defined emitter-detector pairs, the distance between them, the number of time slots, and the frequency of data collection will be displayed.



- Detection distance - moving the slider can define the maximum distance in mm between the emitter and detector to create a measurement channel between them. **Note:** The distance between the emitter and the detector affects the depth of infrared light penetration. Usually, the detection distance is in the range between 20 and 40 mm for ‘long channels’. Increasing the distance above 40 mm can result in lowering the data quality due to very high signal attenuation by the tissue.
- Number of bundles - allows selecting the available number of bundles. One or two bundles can be connected to each device.
- Multiplexing - allows configuring the order of activation of pairs of emitters and detectors in the recording time slots. Click on the 'Multiplexing' button to open the settings window.

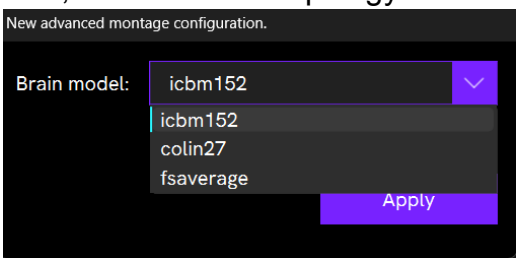
The Apply button first verifies the configuration and reports it to users in case of errors. If the configuration is correct, it will go to the next screen.

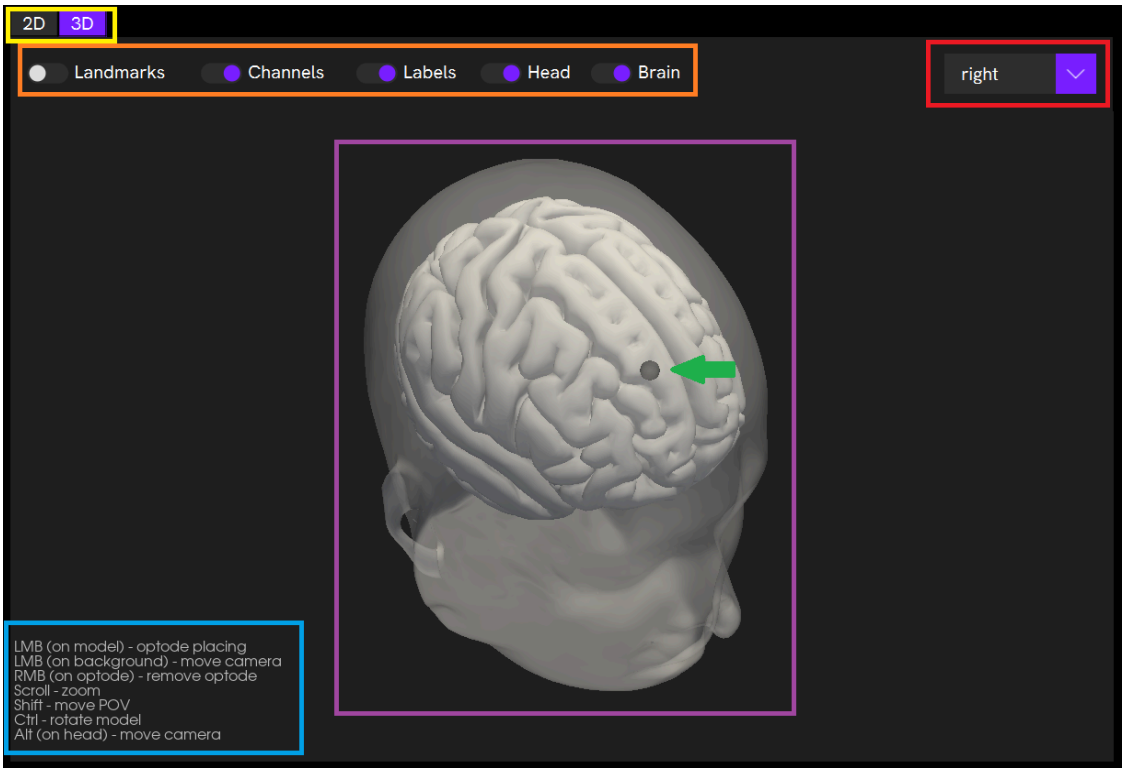
## Advanced Montage Creator

In Advanced Montage Creator mode, users can define more sophisticated montages with an arbitrary position of the optodes, including Diffuse Optical Tomography (DOT) high-density montages or montages with equally spaced optode positions. Another advantage of using an Advanced Montage Creator is the ability to select different head topology templates that are more suitable for your research needs.

**Important: Montages created in the Advanced Montage Creator are not compatible with standard textile caps,** because the Advanced Montage Creator uses arbitrary optode positions. Montages created in the Advanced Montage Creator can be converted to physical caps of different sizes by Cortivision.

First, select a head topology with its associated brain model.

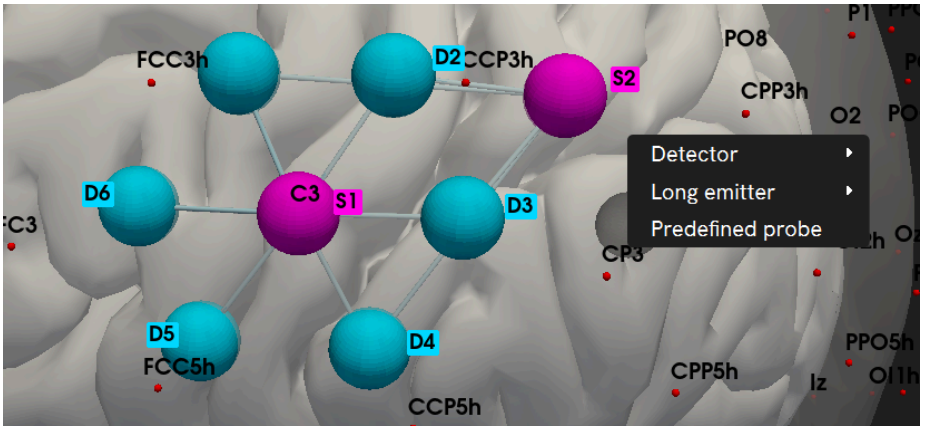


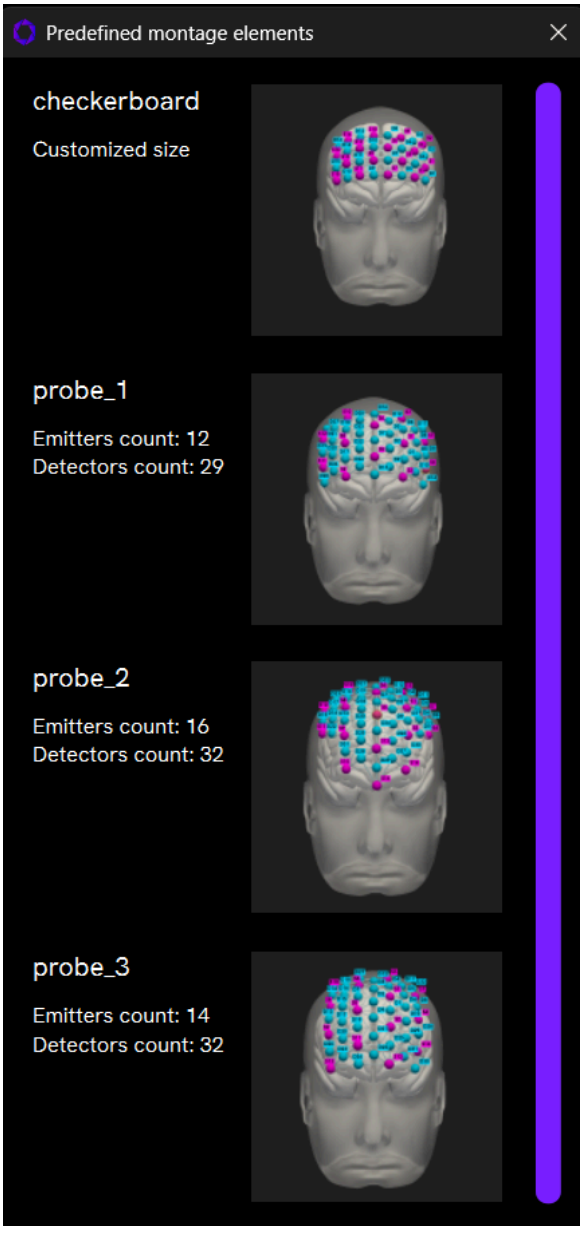

The Advanced Montage Creator window consists of the following items:

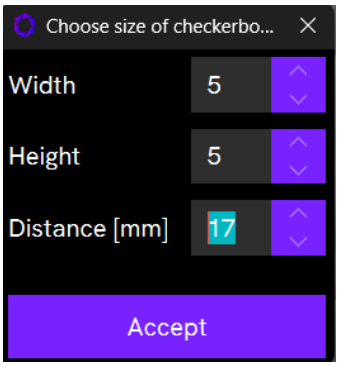
- 2D/3D switch: toggle between either 3D (default) or 2D view
- display settings: turn on or off different graphical elements of the model
- predefined 3D views: revert to standard head positions
- main montage view
- optode cursor
- keyboard and mouse button functions tooltip

Click on the left mouse button to place an optode, then choose Long emitter or Detector. If the distance between the Emitter and the Detector is shorter than a specified detection distance, channels will be added automatically.



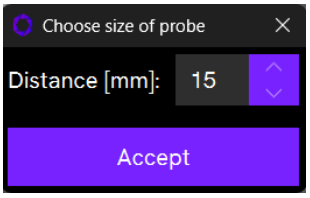

Choosing the Predefined Probe will bring up a new pop-up. This feature allows you to place multiple optodes arranged in a predefined pattern. Choose an appropriate pattern




The Checkerboard pattern allows you to create a rectangular array of optodes with an equal spacing defined by the Distance parameter.

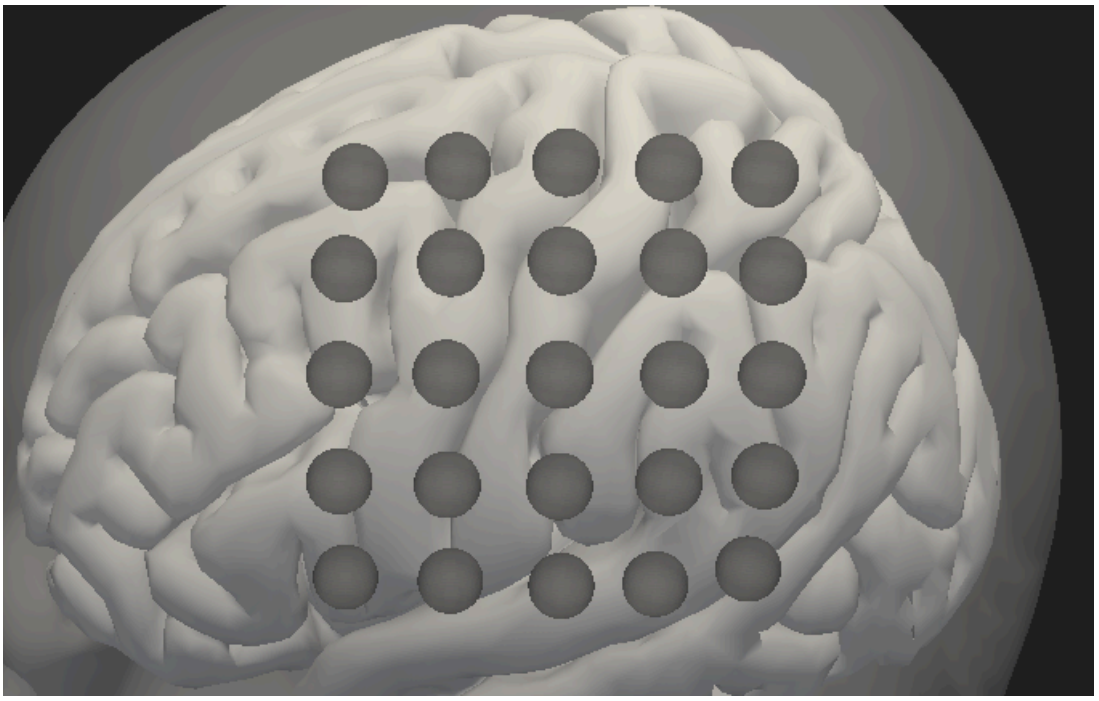
The emitter and detector count is displayed for the rest of the predefined probes, since only a checkerboard probe has a variable optode count.

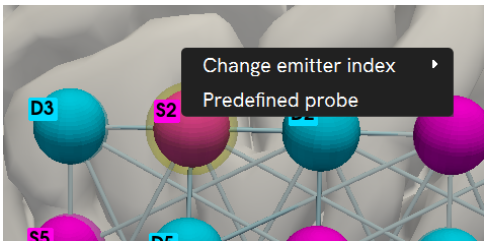



For other probe patterns, you can define the interoptode distance.

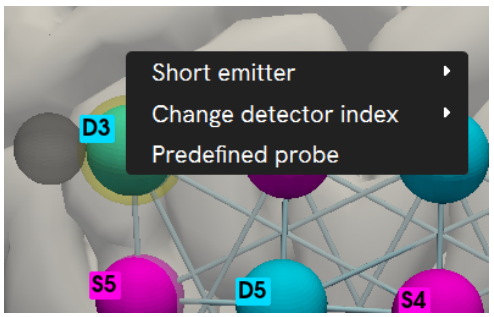
Please note that a minimum interoptode distance is 15 mm. Shorter distances are not possible to achieve due to the physical size of the optodes and their holders. This does not apply to short channels. Short channels can still be placed with a fixed 10 mm distance.

After choosing the desired predefined probe, the optode cursor shows the approximate position of the optodes on the head.
**Important: final position of the optodes could be slightly different because it is calculated using an ARAP[2] algorithm that minimizes errors of the interoptode distance mismatch caused by head curvature.**
You can use the [Q] and [E] keyboard buttons to rotate the probe if needed.
Then, click on the left mouse button to accept the position of the optodes.






When hovering the mouse over the placed optode, a yellow halo effect appears around it. Click on the left mouse button to open a context menu that allows you to change the optode index (swap optode numbers).



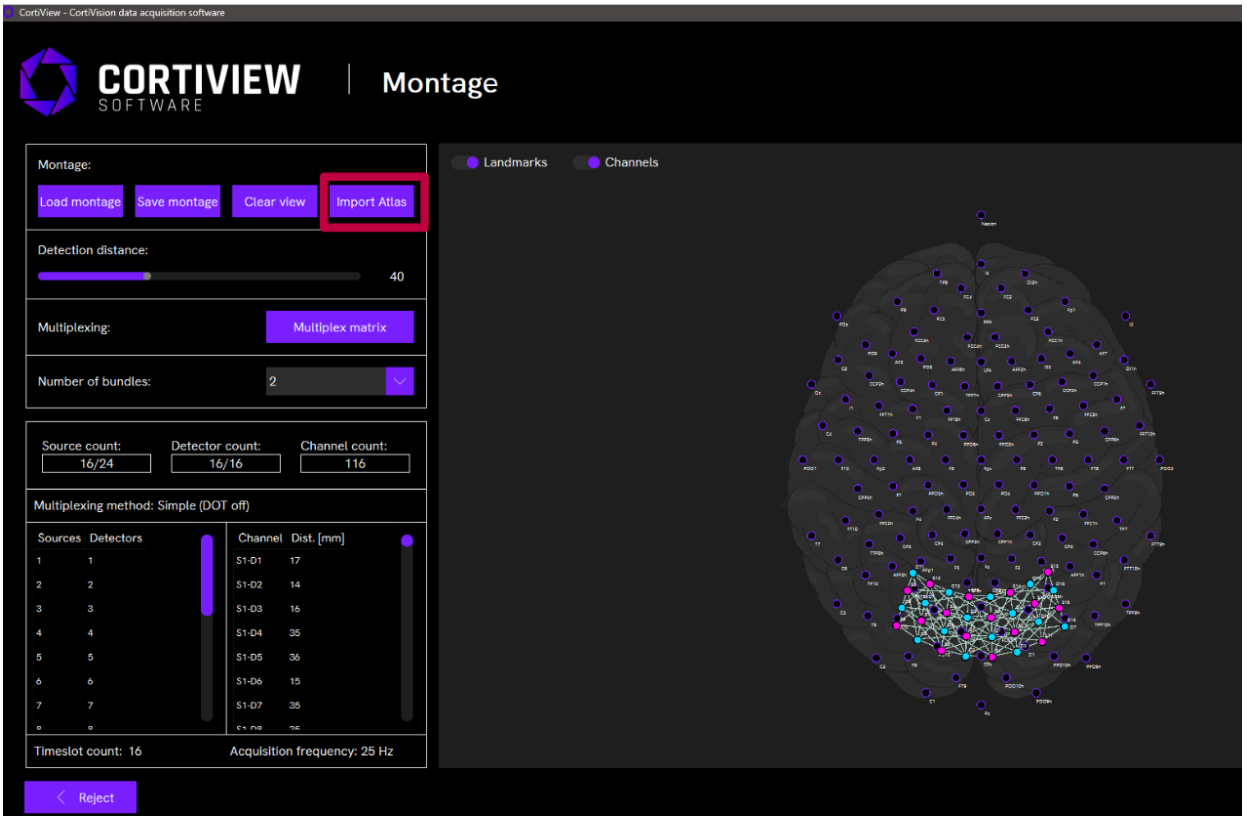

If hovering over the detector, a gray cursor together with the yellow halo appears. This allows you to place a short emitter attached to the highlighted detector.

Use the right mouse button to delete the optode.

[2] As-rigid-as-possible algorithm. Since ARAP algorithm is cuputationally intensive, the exact position of the optodes is calculated after their final placement. Before that a simple projection to normals is used to speed up the visuals.

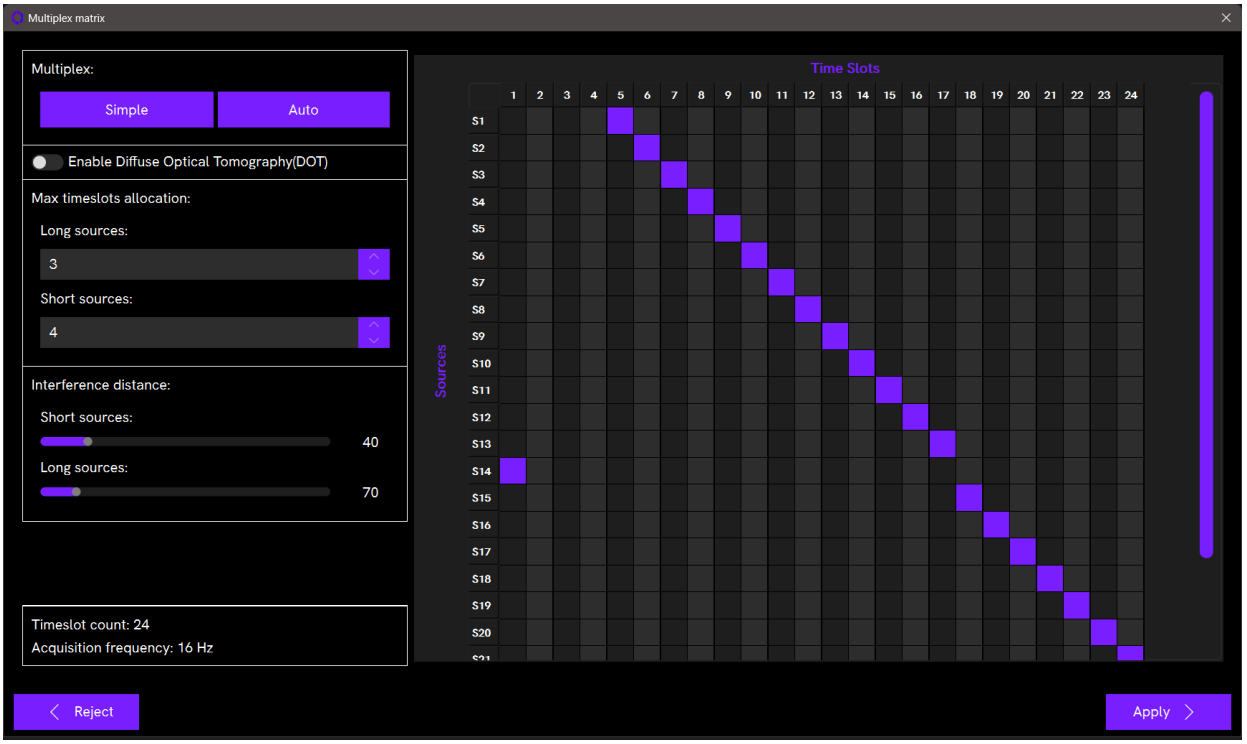
## AtlasViewer montage import

Select an SD file to import a custom-designed montage created using the AtlasViewer.




AtlasViewer is an open-source MATLAB application for the display of fNIRS data on atlas anatomy. It can also be used to design an fNIRS probe, verify its sensitivity, and provide a way of converting the probe to a physical 3D-printed cap (NinjaCap). For more information regarding the creation of high-density DOT caps refer to the AtlasViewer wiki page, and especially the NinjaCap design, SDgui, and 3D Source Detector Geometry tutorials.

## Multiplexing matrix settings




By choosing the 'Simple' button in the single time slot, only one emitter will send out light that can be received by the detectors that form a measurement channel.

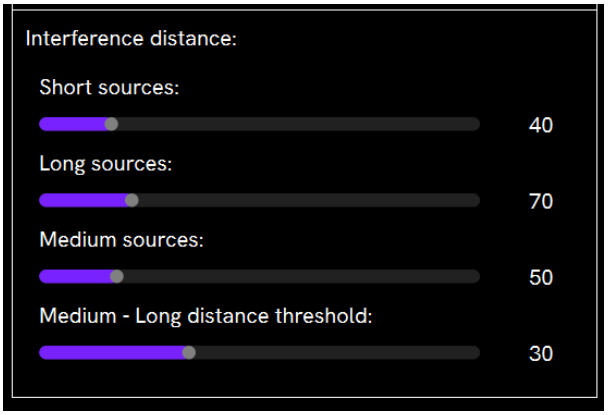
You can click on the corresponding cell in the table to move a desired emitter to another time slot. Empty time slots will be automatically removed from the final multiplexing matrix, increasing the sampling frequency.

Alternatively, you can select the 'Auto' option, which will activate emitters located at a considerable distance from each other in the same time slot. The minimum distance between simultaneously activated emitters can be defined using the 'Interference distance' sliders, separately for long and short channels.

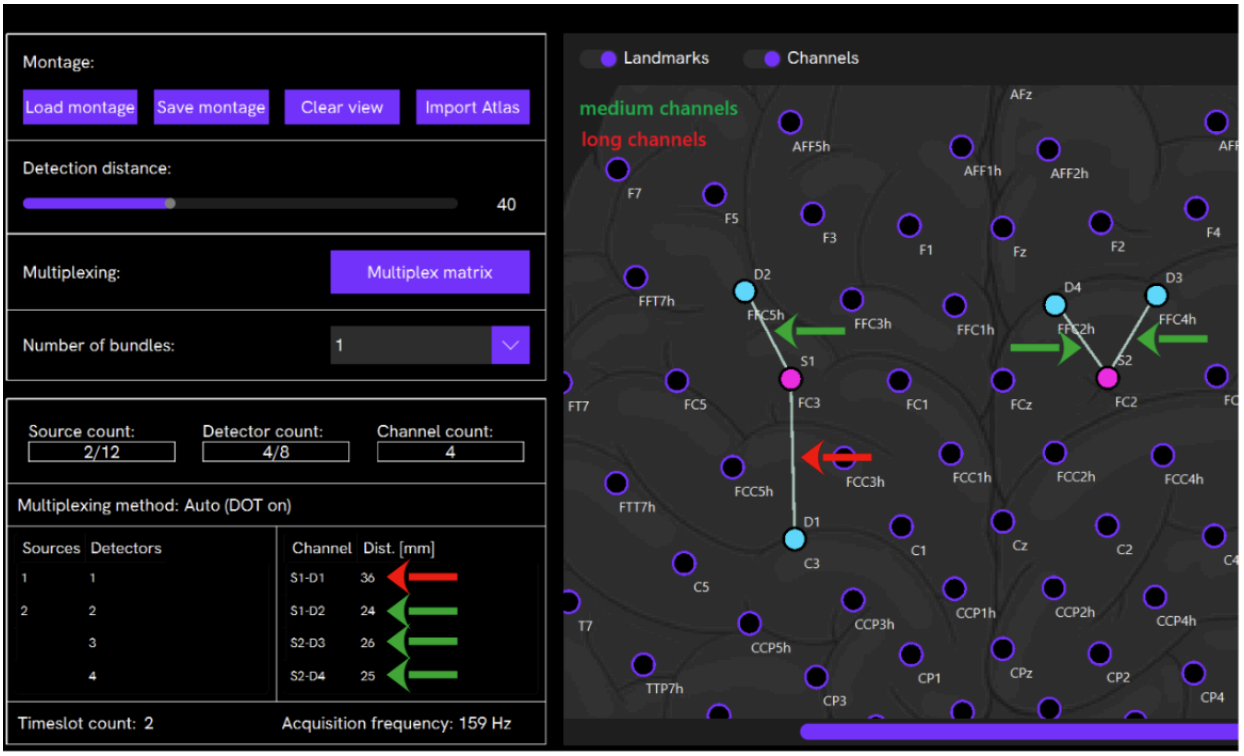
The number of time slots used for long and short channels can be adjusted in the 'Max timeslots allocation' panel.

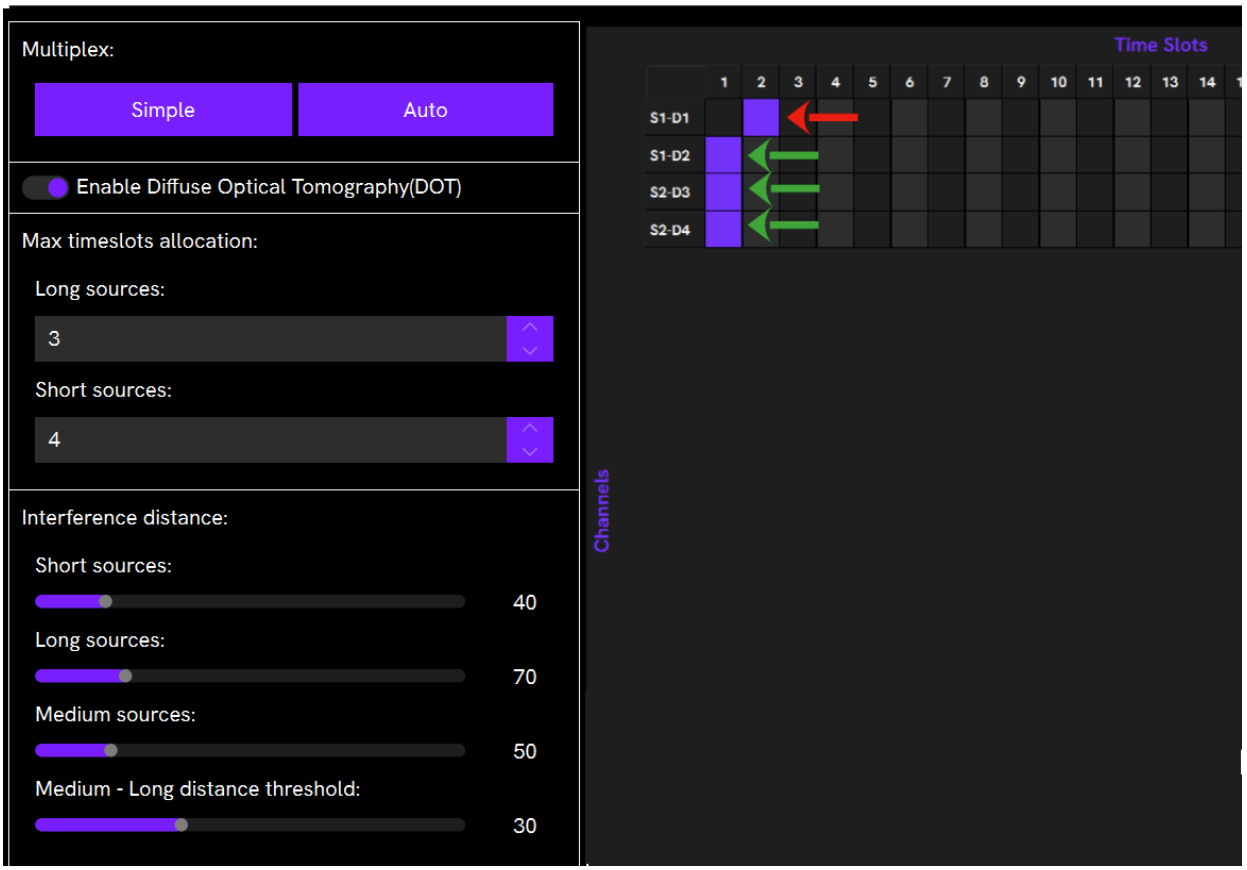
The effect of changes in the mentioned parameters on the number of time slots utilized, as well as the frequency of signal acquisition, can be observed in the lower left panel and in the visualization of emitter and detector activation patterns (right panel).

For montages with extremely diverse source-detector distances (e.g. 16-36 mm), there is an option to enable Diffuse Optical Tomography (DOT) multiplexing matrix calculation. When this option is selected, each emitter can be assigned to two different time slots, thus enabling two different emitter power settings.




If the DOT option is enabled, an additional slider, Medium-Long distance threshold, appears in the 'Interference distance' group box, allowing the user to set the threshold at which individual channels are included in a given time slot.z Enabling the DOT feature will optimize the calibration and signal quality for montages with high diversity in source-detector distances for the same emitter.






Note that when the DOT feature is enabled, the rows of the Time Slots table show channels, not emitters.

# Recording data

**Before starting the signal recording, the device must be turned on and connected to the same network as the data acquisition laptop.**

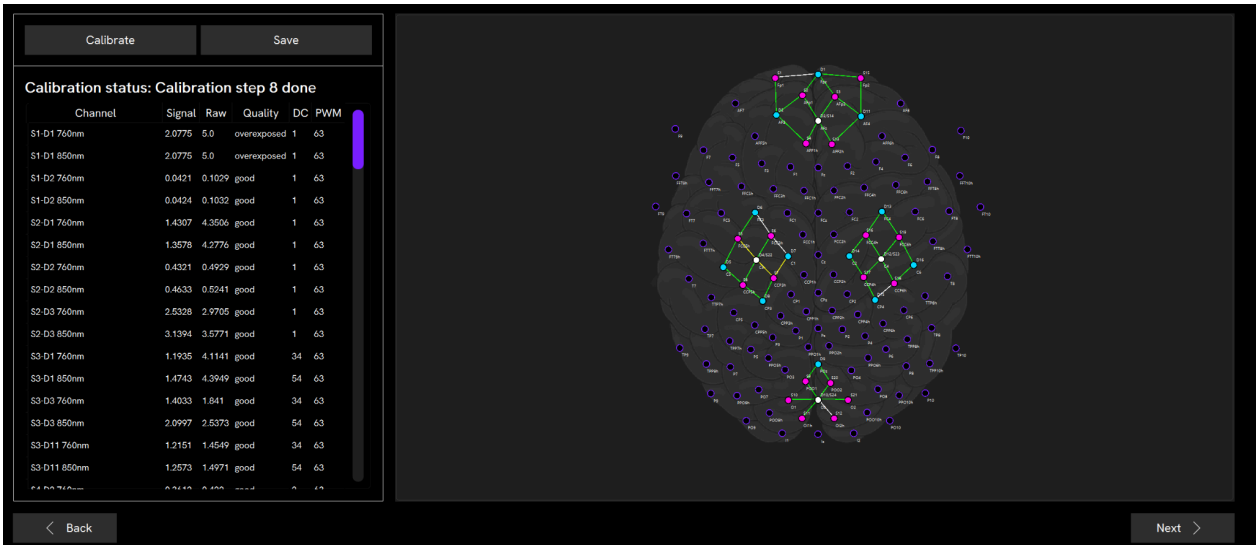
After selecting the correct user template, press Next, and the application will search for a device connected to the same WiFi network.



If the device is detected, its serial number will be displayed in the list of visible devices. If necessary, you can repeat the process by pressing the Retry button. Then, click on the Connect button. The application will be connected to the device at this point, and the LED on the amplifier will change from **red** to **green**.

# Calibration

The next window will begin the calibration process of adjusting the light gain to the detectors' operating range to get the best signal-to-noise ratio. The calibration process takes several steps, as indicated by the calibration status displayed on the left.




The table on the left provides information regarding the signal quality parameters of each channel, which includes:

- Signal - Value of the light intensity in volts with the dark noise subtracted
- Raw - Value of the light intensity in volts, including the dark noise
- Quality - Descriptive data quality value based on signal-to-noise ratio metric
- DC - Emitter intensity value in arbitrary units. The minimum intensity is 1, the maximum intensity is 52 for 760 nm and 63 for 850 nm. The intensity value is calculated with the following equation: I(DC) = DC/63.
- PWM - Additional mechanism for adjusting the emitter intensity using Pulse Width Modulation. This mechanism applies only to short channel time slots. The minimum intensity value for PWM is 1, the maximum intensity value is 63. The intensity value is calculated with the following equation: I(PWM) = PWM/63.

In addition, the signal quality of each channel is expressed by colors in the visualization on the right panel:

**White lines** - indicate an overexposed channel, i.e. the incoming light exceeds the dynamic range of the detector.

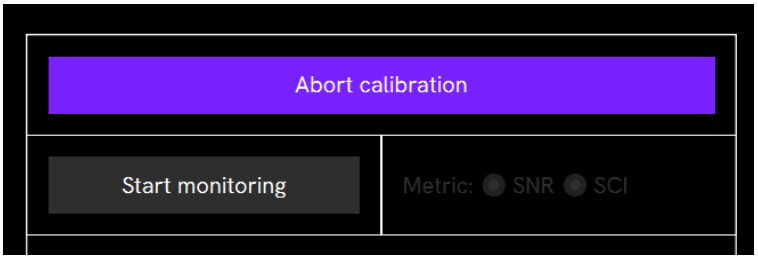
**Red lines** - indicate channels that contain a significant noise component. One of the most common reasons is the lack of contact between the skin and the optode, for example, due to the hair under the optode surface.

**Yellow lines** - moderate signal quality, that is, the presence of an acceptable noise level in the signal. Channels labeled as yellow are worth checking for possible sources of interference.

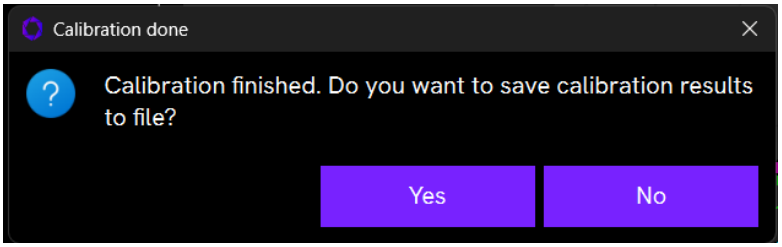
**Green lines** - good signal-to-noise ratio.

**If there is a need to change the position of the optode (e.g., when removing hair underneath the optode), the calibration should be repeated before proceeding to the next steps by clicking the Calibrate button again.**

If you spot many bad channels during calibration, you can click the Abort calibration button to save time, readjust the optodes, and calibrate once again.




Once the calibration is finished, the pop-up window will appear. You can save the calibration results to a file by selecting 'Yes'. Click on No to close the window. Press Next to proceed to the measurement window.



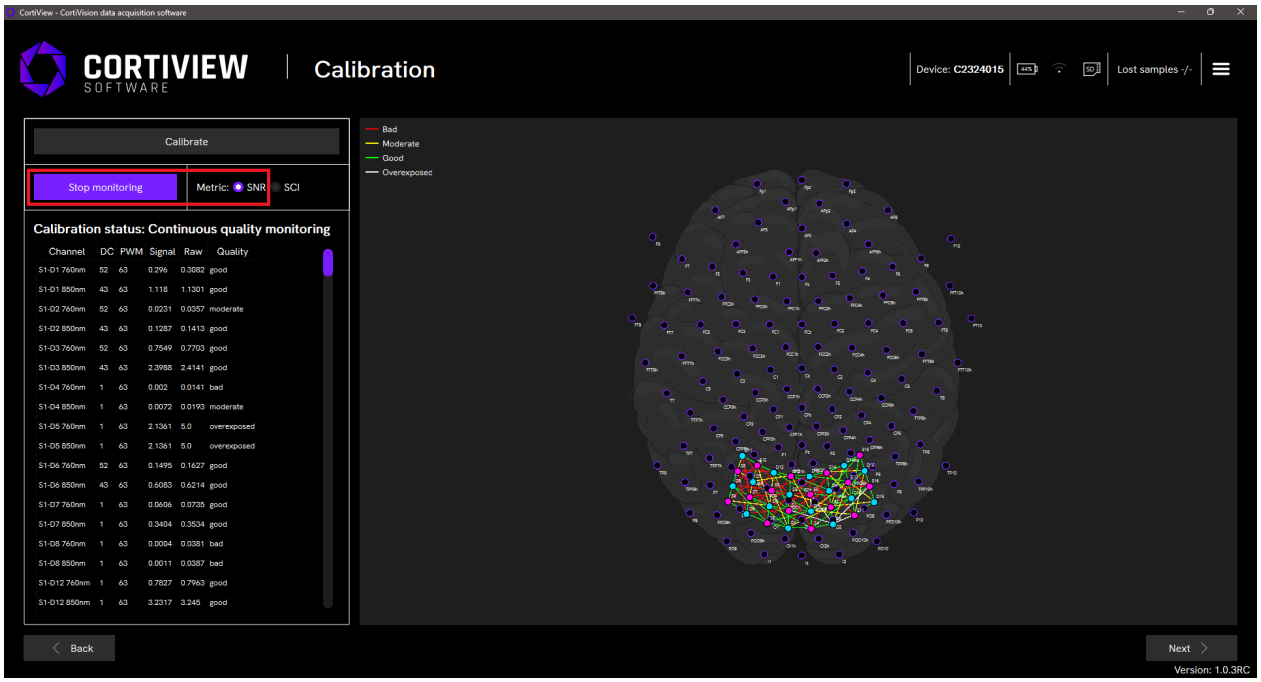
## Signal quality monitoring

After the calibration, there is a possibility to monitor the signal quality in real time by using one of the following metrics:

- the signal-to-noise ratio (SNR)
- the scalp coupling index (SCI)

### Signal-to-noise ratio

Click on Start Monitoring to view changes in the SNR over time to identify potential channels with poor signal quality. The Signal-to-Noise ratio metric is defined as the ratio between the mean signal intensity and the standard deviation of the noise of the detector. Signals with a mean value of 40 mV are considered ‘good’ (SNR above 50 dB). Signals with a mean value between 40 and 5 mV are considered ‘moderate’ (SNR between 30 and 50 dB). Signals below 5 mV are considered ‘bad’ (SNR below 30 dB).

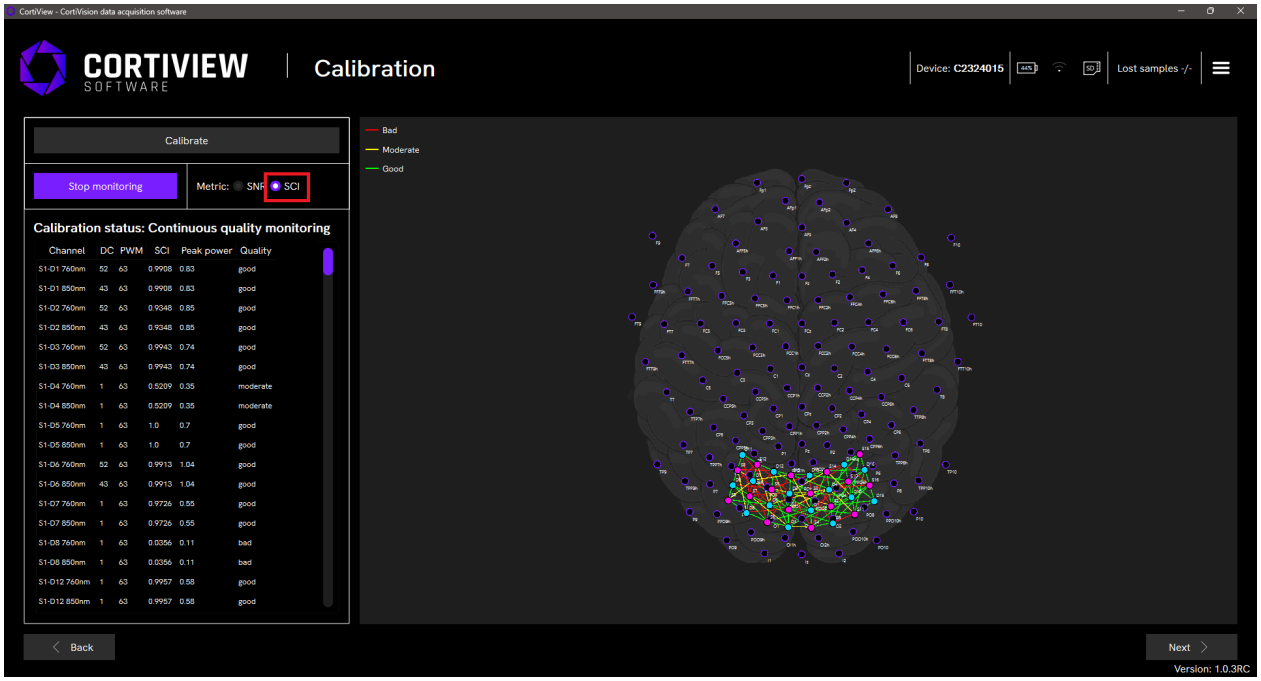



Please note that the SNR metric does not take sampling frequency into account. If using montages with low time-slot count, the sampling frequency of the signal will be significantly higher than a physiological signal of interest (an fNIRS signal). Using a low-pass filter during the analysis will increase the SNR by averaging between samples. Therefore, the SNR metric tends to underestimate the signal quality when using a high signal acquisition frequency.

## Scalp Coupling Index

When the Signal monitoring function is enabled, click on the SCI radio button to switch to the Scalp Coupling Index metric. This measure is used to assess the strength of cardiac oscillations in raw light intensity. The calculation is made by determining the signal correlation of two wavelengths λ1 and λ2 for the same channel (yλ1 and yλ2). This is then normalized by the standard deviations of the corresponding signals σλ1 and σλ2[3],[4].

$$SCI = y\lambda1/\sigma\lambda1 * y\lambda2/\sigma\lambda2$$




The threshold values (i.e. values that determine good, moderate, and bad signal quality) for SCI could be set in the acquisition template settings panel.

The difficulty with using SCI is that the coefficient is sensitive to motion artifacts, which can lead to a false estimate of SCI. Peak power (PP) has therefore been introduced as a solution to this problem. PP allows the quantification of the spectral power of the correlated signal (Pollonini et al., 2016). The default PP threshold value could be set in the acquisition template settings panel.

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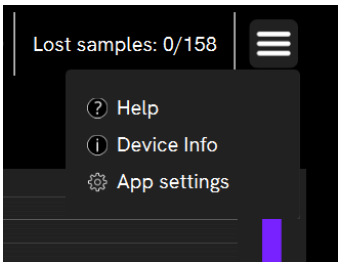
[3] Pollonini, L., Olds, C., Abaya, H., Bortfeld, H., Beauchamp, M. S., & Oghalai, J. S. (2014). Auditory cortex activation to natural speech and simulated cochlear implant speech measured with functional near-infrared spectroscopy. *Hearing Research*, *309*, 84–93. https://doi.org/10.1016/j.heares.2013.11.007

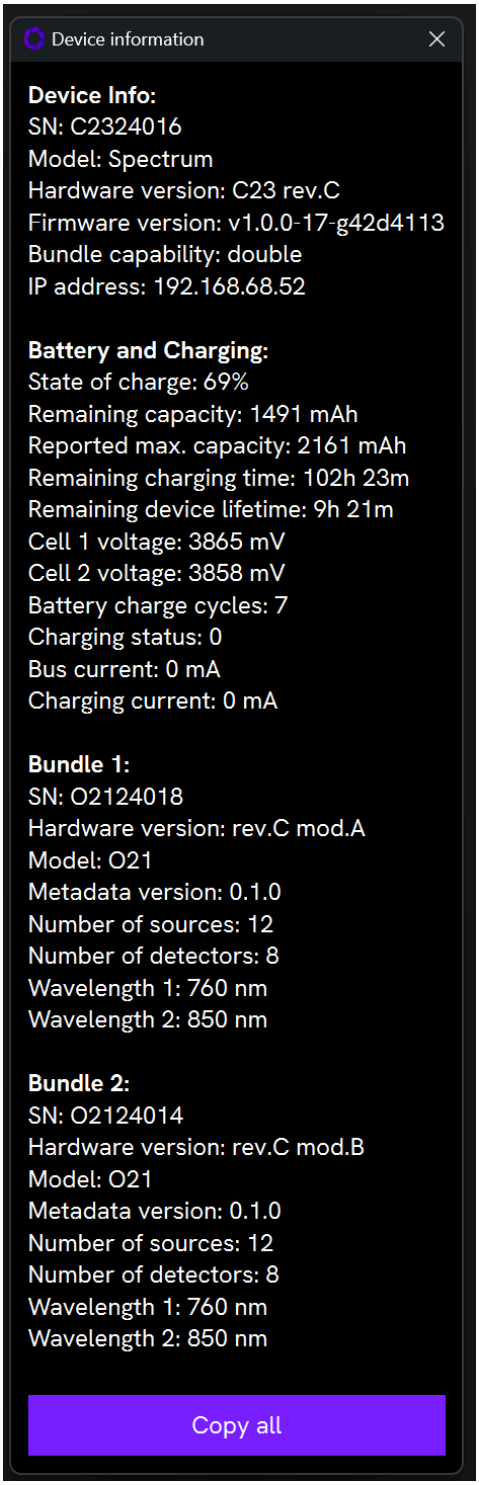
[4] Pollonini, L., Bortfeld, H., & Oghalai, J. S. (2016). PHOEBE: A method for real time mapping of optodes-scalp coupling in functional near-infrared spectroscopy. *Biomedical Optics Express*, *7*(12), 5104–5119. https://doi.org/10.1364/BOE.7.005104

# Measurement

In the main measurement window, it is possible to monitor the device's battery level, WiFi signal strength, SD card capacity, and the number of lost signal samples by **moving the cursor over the corresponding icons** in the upper right window of the application.
If the LSL option is enabled in the measurement template settings, the LSL section of the status bar is available. Symbol (X) means no suitable LSL input marker stream is present. The symbol ∞ means the LSL marker stream is found.

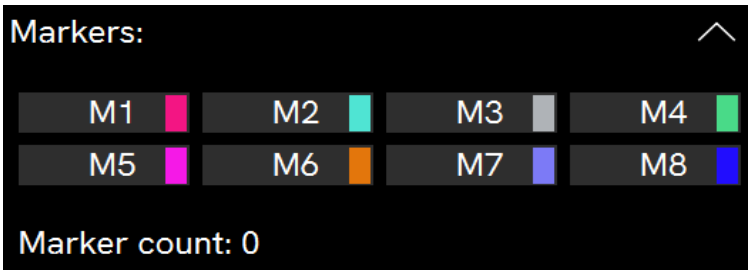

By clicking on the ☰ button additional commands are available.
Help - access to the user manual PDF file
Device info - extended device, bundle, and battery properties.
App settings - global application settings.




The device information panel shows the device, bundle, and battery properties. Click on the Copy All button to copy device information to the clipboard. You can use this information when contacting support.

On the left are settings that change the parameters for displaying and recording the signal:

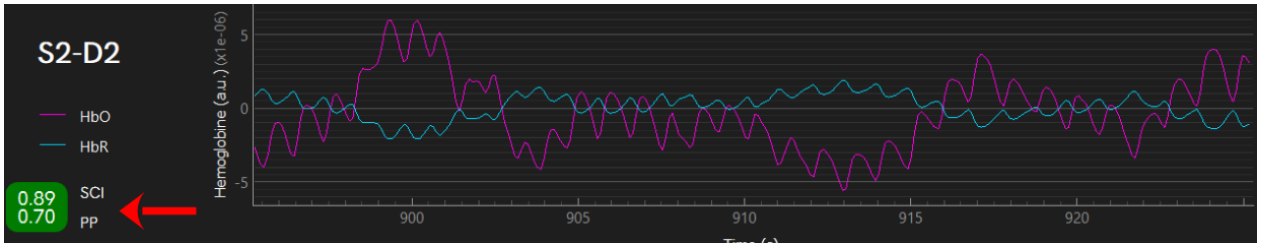
- Plotting - allows the signal to start or stop being displayed in the application window.
- Baseline - after displaying the signal by pressing this button, a baseline can be set for further signal flow.
- Recording - if the signal is displayed, the recording can be initiated by pressing this button and naming the output file. The time since the start of recording is also visible during active recording.
- Display mode - allows switching between displaying the raw signal (light intensity) and changes in hemoglobin concentration.
- Traces - allows switching between displaying the intensities of two wavelengths (light intensity) or HbO/HbR concentration.
- Channel selector - allows you to select which channels are displayed on the plot.
- Filters - allows the application and setting of low-pass and/or high-pass filters on the displayed signal.
- Markers - allows manual entry of markers in the record by pressing the marker icon.



# Scroll chart

Each channel is presented on a separate chart. Therefore, the scale of charts is adjusted to the range of the data from specific channels.


The Scalp Coupling Index (SCI) and the Peak Power (PP) show values for individual channels. You can enable or disable this feature in the Settings tab on the User Template screen.



# Stacked chart

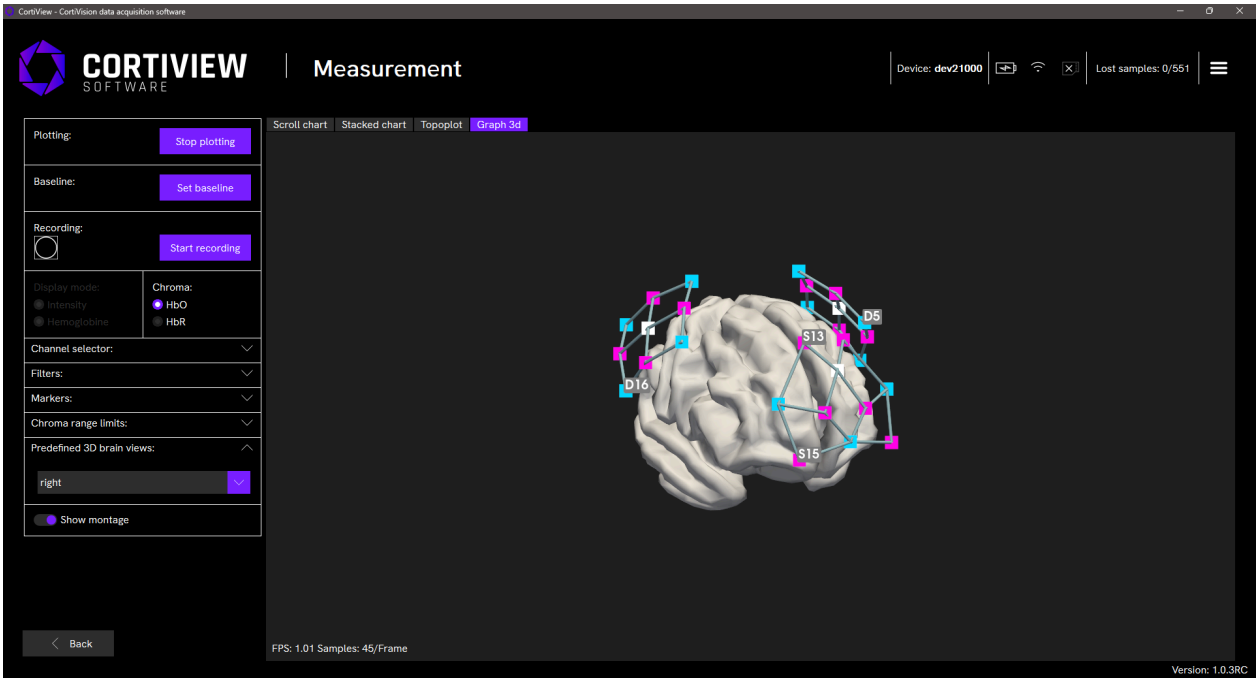
The measurement channels are shown on a single chart with a common scale for all traces. Below the fNIRS channels, the joint chart for all axes of the accelerometer and gyroscope is presented.

## Topoplot

Changes in raw intensity or hemoglobin values are displayed in real-time for each channel in a 2D view.


## Graph 3D

Changes in intensity/hemoglobin values are displayed in real-time for each channel in a 3D view.

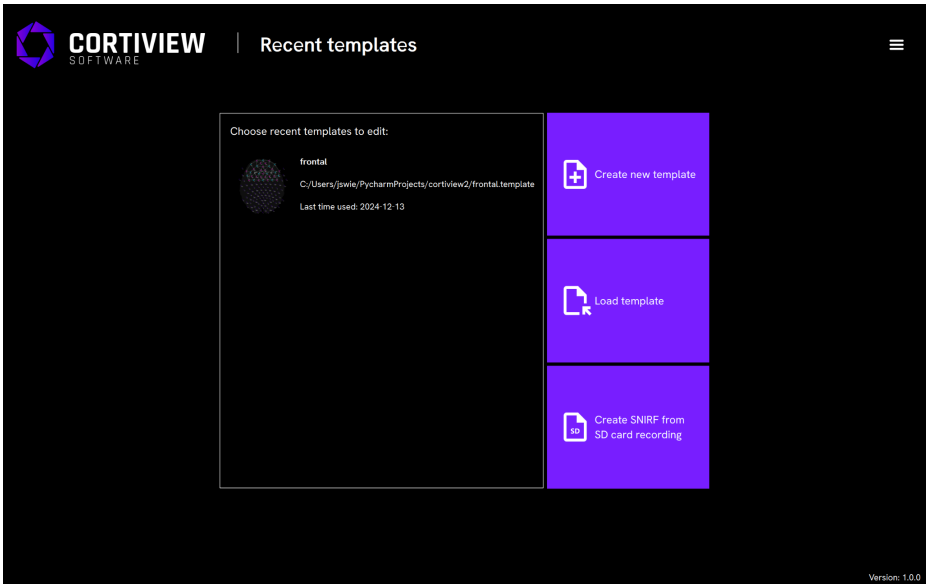


# Memory card options

The data recorded on the memory card can be used to retrieve lost samples in the signal stored on the data acquisition computer.

Options for creating a new file using the data stored on the memory card are located in the first window after CortiView 2 is launched.

1. Click on ‘Create SNIRF from SD card recording’.




2. In the open window, select the paths to the SNIRF file to be repaired and the path to your SD card or the path to a local folder that contains *.bin and *.config files data from the SD card. Click on the Convert button to finalize the process.

# Format of the output files

CortiView 2 creates two types of output files in the directory assigned while defining the registration template.

1. **Shared Near Infrared Spectroscopy Format** (SNIRF) files (*.snirf)

   The fNIRS community designs SNIRF standards to facilitate the sharing and analysis of NIRS data.

2. **CortiView 2 temporary files** (*xxxxx_data.bin; *xxxxx_markers.bin; *xxxxx_meta.json)

   Temporary files contain the raw signal, markers, and recording parameters. If the SNIRF file is damaged or missing, temporary files can be used to recover the data and then converted into a new SNIRF file. These files are located in %userprofile%\cortiview2\ folder. To convert temporary files to SNIRF, please contact Cortivision Support.

# LSL format *(in progress)*

Cortiview provides 1 LSL inlet for markers (integer from range 1-256) and 3 LSL outlets:

1) raw - contains raw fNIRS data of two wavelengths from all defined channels (num_of_channels*2 values) + IMU data (6 values) from the accelerometer and gyroscope.

Packet format:

<channel1_760nm><channel1_850nm><channel2_760nm><channel2_850nm>...<accelerometer_x><accelerometer_y><accelerometer_z><gyroscope_x><gyroscope_y><gyroscope_z>

2) mirror - contains received marker

TBC

# Remote control

It is possible to control the application via REST API on port 8888 remotely. You can change the default REST API port in the application settings if needed.

POST /connect - Deprecated for backward compatibility. Starts plotting, , example: http://localhost:8888/connect

POST /disconnect - Deprecated for backward compatibility. Stops plotting, , example: http://localhost:8888/disconnect

GET /health - connection test, example: http://localhost:8888/health

POST /startRecord - starts recording, requires filename parameter, example: http://localhost:8888/startRecord?filename=abc

POST /stopRecord - stops recording, example: http://localhost:8888/stopRecord

POST /toggleMarker - marker switching (1-256), requires id parameter example: http://localhost:8888/toggleMarker?id=1

# Troubleshooting

Diagnostic information about the operation of the application can be found in the logs directory at %userprofile%/cortiview2/cortiview.log. Log files are automatically rotated, storing a maximum of 5 files, each 10MB.

CortiView 2 application is divided into the backend and frontend parts. The backend is responsible for the device connectivity, low-level, and disk writing activities. The front part interfaces directly with the user via the Graphical User Interface. Therefore, there are two separate log files generated:

‘%userprofile%\cortiview2\cortiview-backend.log’ for the backend.

‘%userprofile%\cortiview2\cortiview.log’ for the frontend.

In case of problems with self-diagnosis, please send a description of the problem along with the packed cortiview.log file to support@cortivision.com

# CORTIVISION



**More info:**
www.cortivision.com
sales@cortivision.com