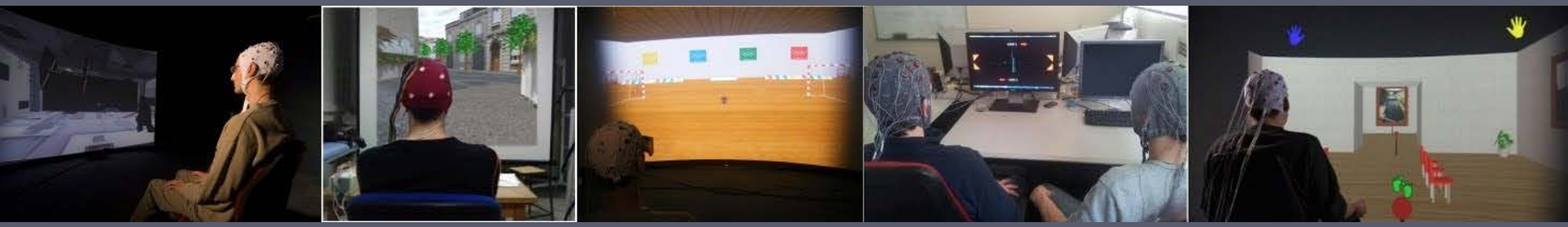
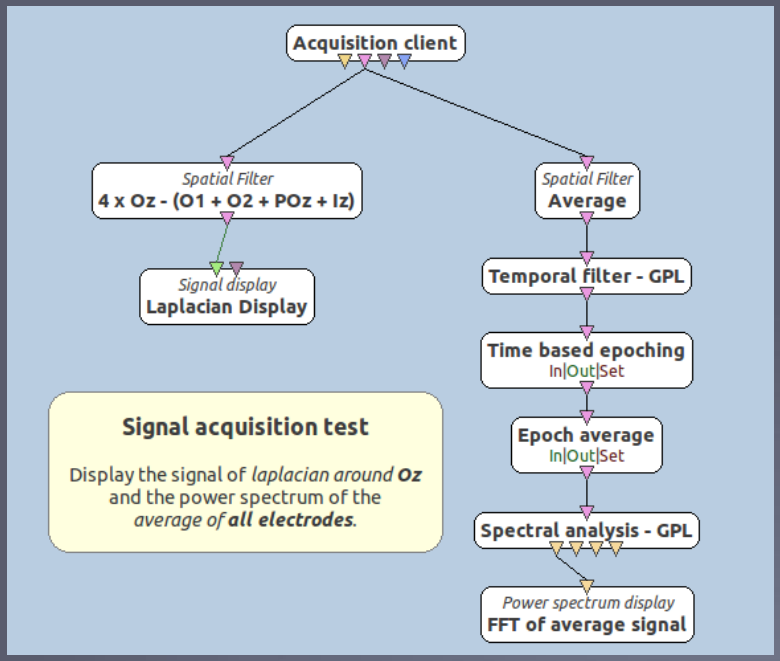




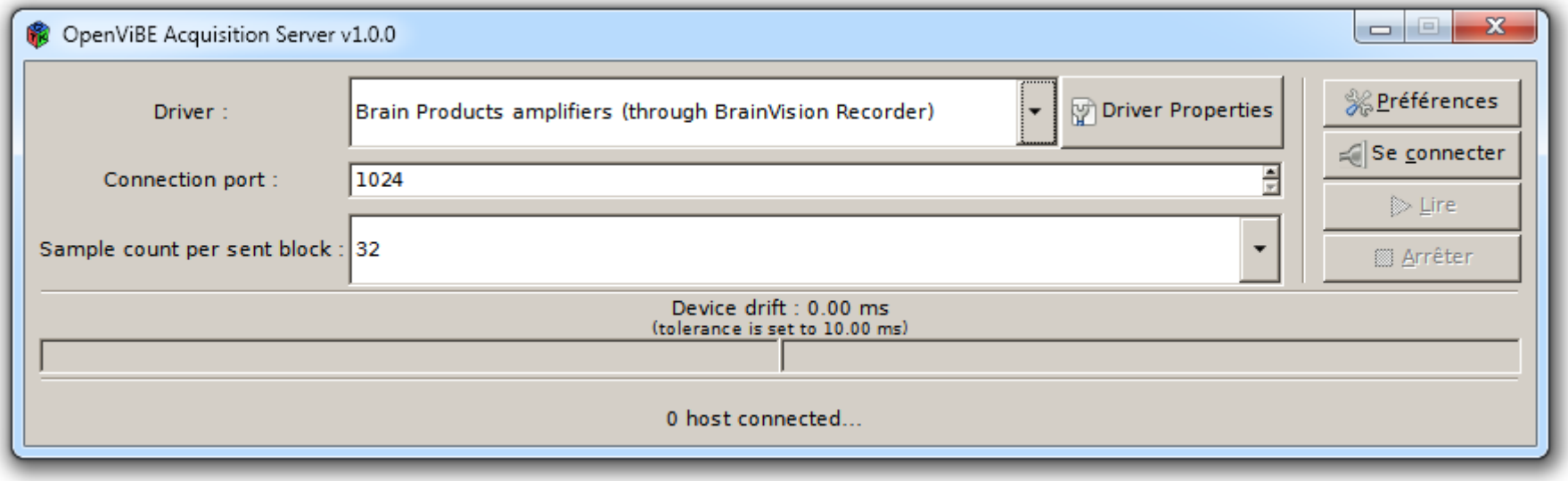
An introduction to OpenViBE: Basic EEG signal acquisition, processing and visualization

Fabien LOTTE,
Inria Bordeaux Sud-Ouest
LaBRI (Univ. Bordeaux-CNRS-Bordeaux INP)

The OpenViBE tool to read brain signals

The OpenViBE **acquisition server**

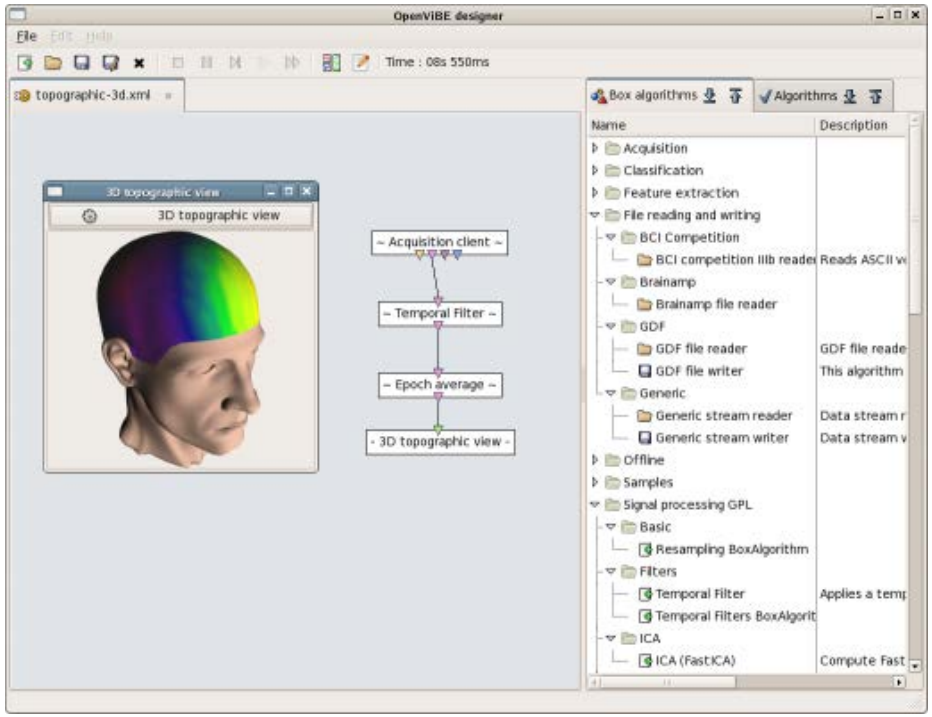
- A generic interface to read from multiple devices
- 40+ brain recording devices supported, and growing!



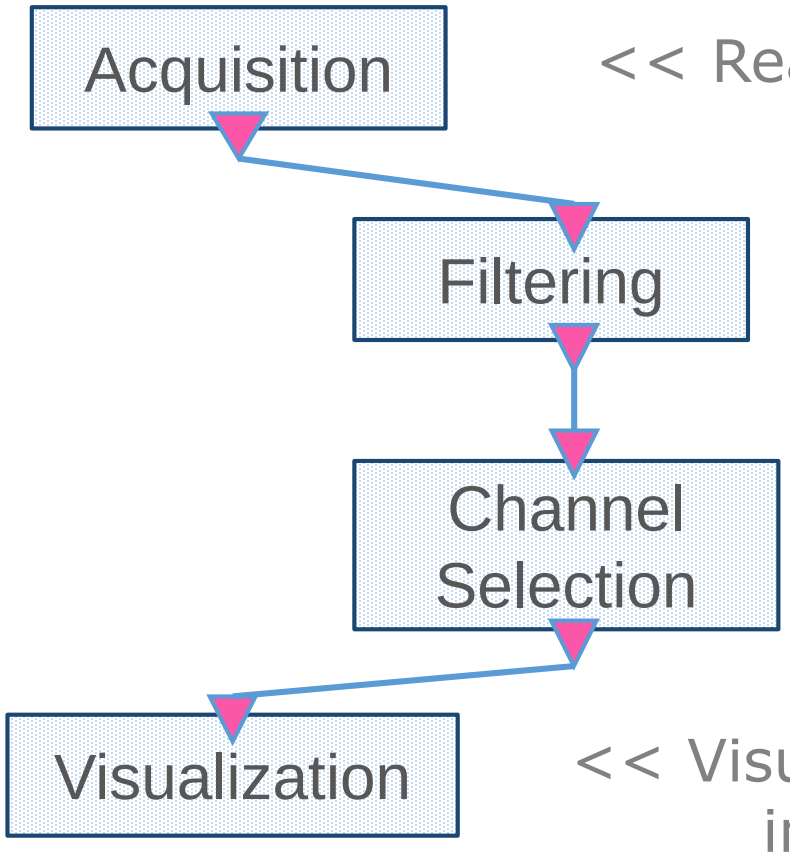
The OpenViBE tool for designing BCIs

The OpenViBE **designer**

- Creating a BCI by assembling boxes
- One box = one processing module



The OpenViBE designer: an example



<< Reading EEG signals being measured

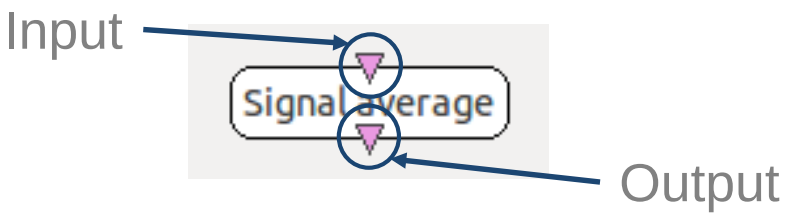
<< Filtering EEG in a given frequency band

<< Selecting sensors

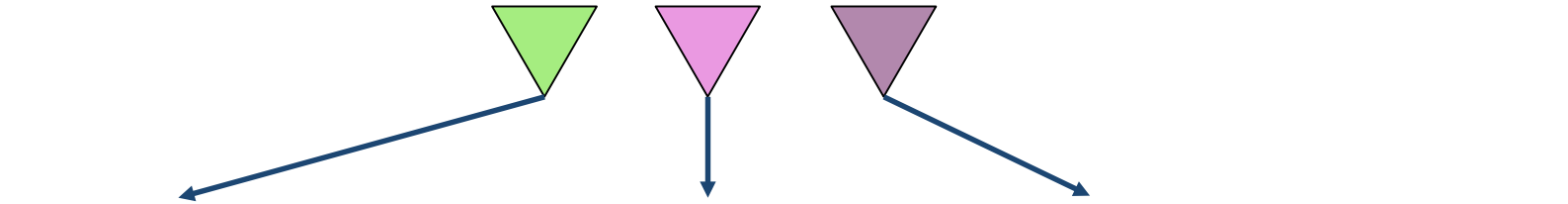
<< Visualizing processed signals in real-time

An OpenViBE box

- Box Input-Output



- Data types



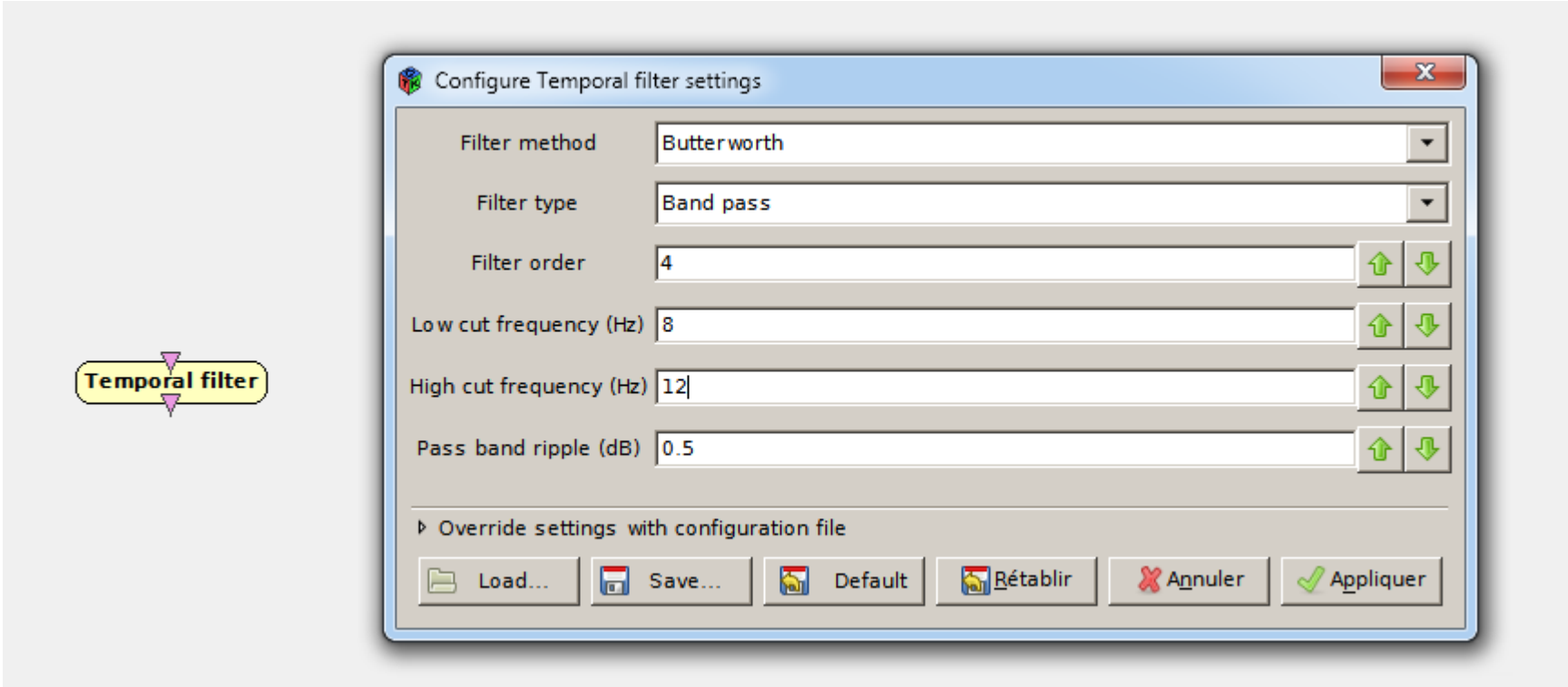
Streamed matrix
(data matrix)

Signal
(Data with a sampling rate and channels – subtype of streamed matrix)

Stimulation
(Event with a name and a date)

Box settings

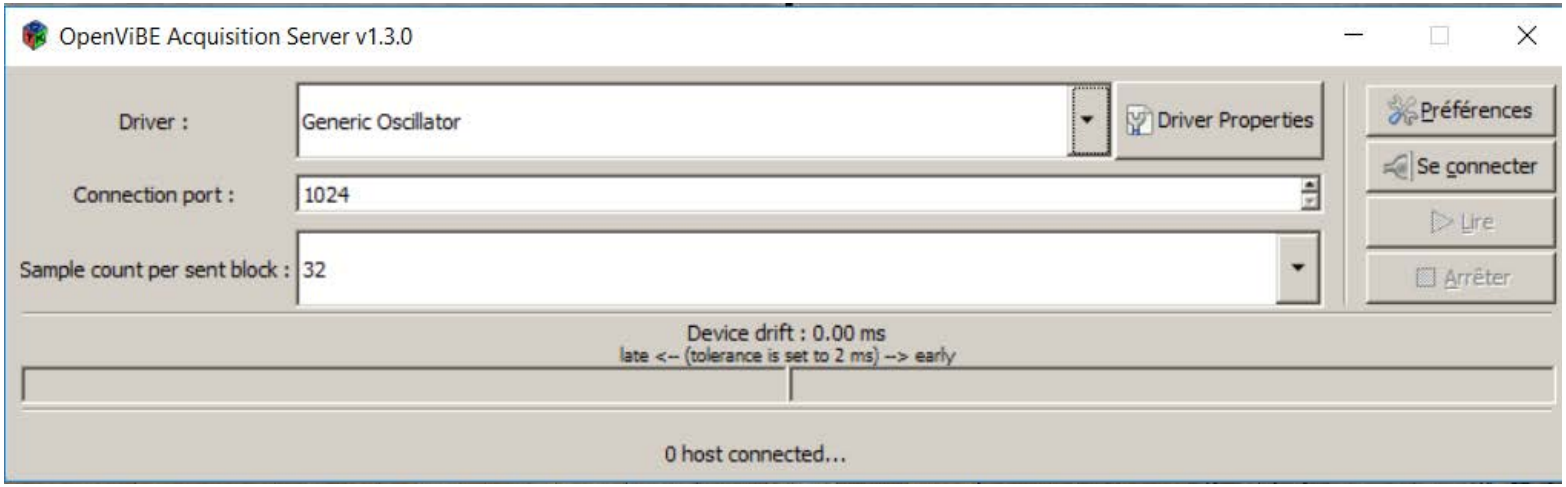
- Settings are available by double-clicking on the box



Exercise 1

- Warm-up: display EEG signals by

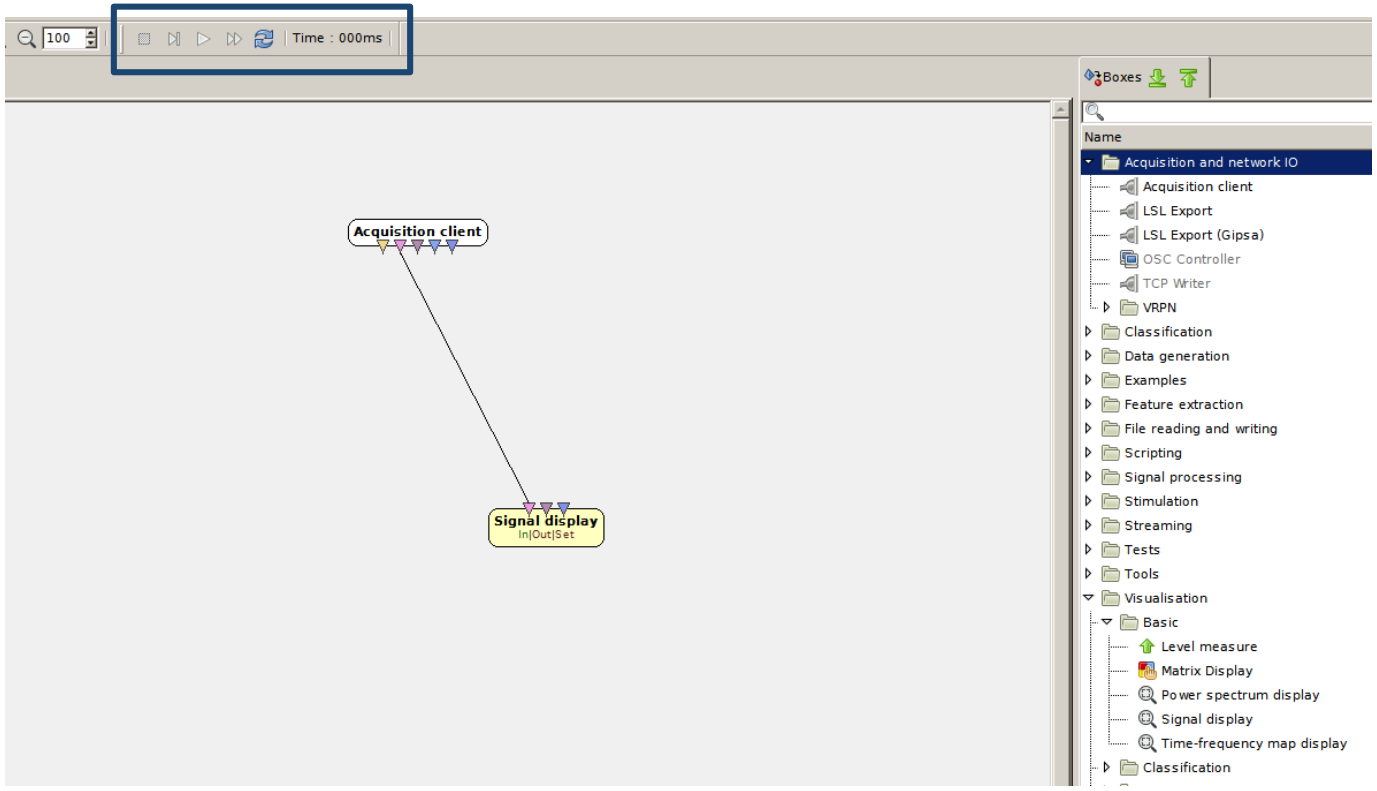
  1. Selecting “Generic Oscillator” as driver in the acquisition server then “connect” then “read”



Exercise 1

2. copying the OpenViBE scenario below and running it (play)

Control panel: Start and stop the BCI!

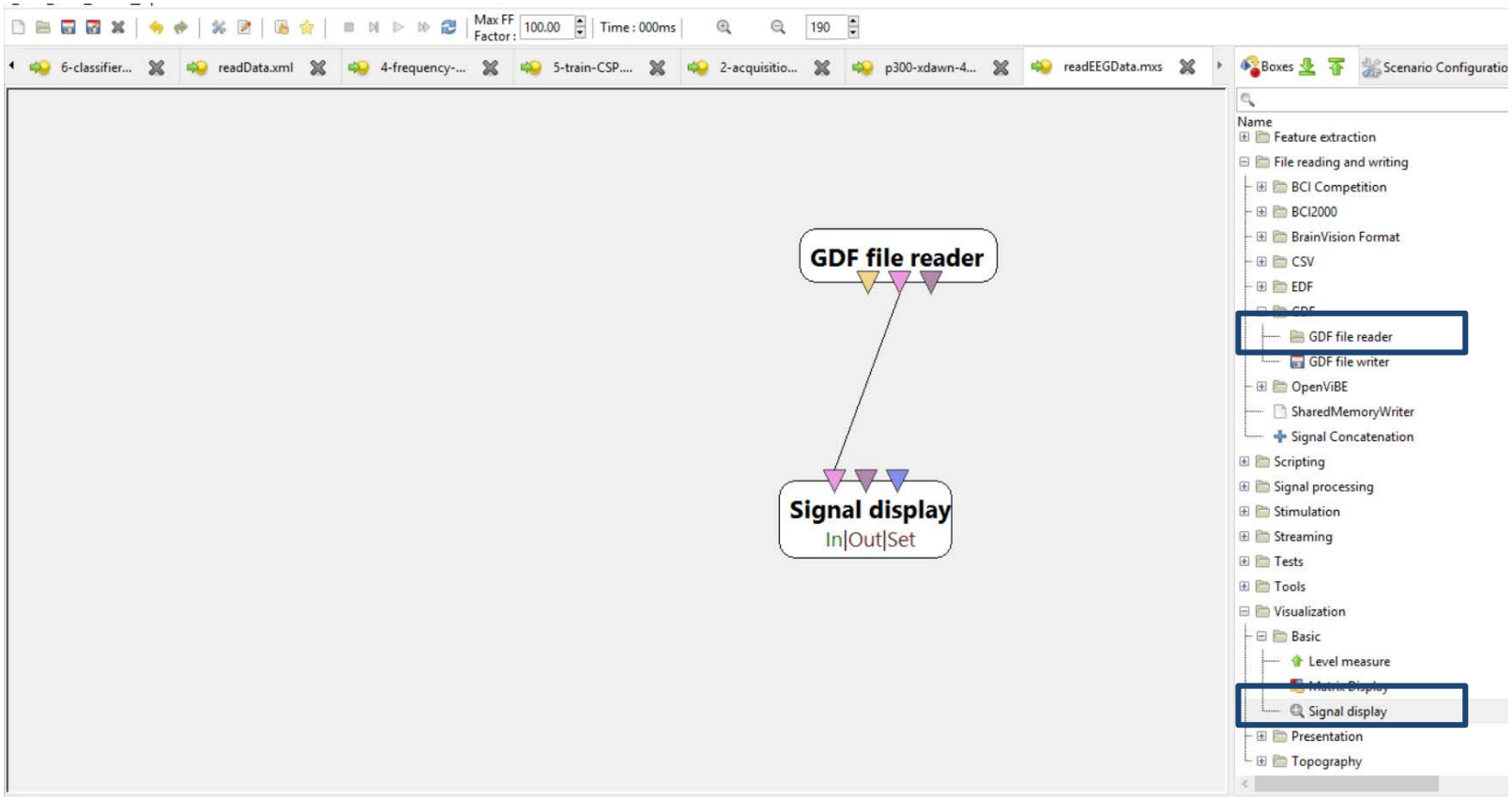


Scenario edition zone: arrange boxes there!

Box selection zone: search and select boxes!

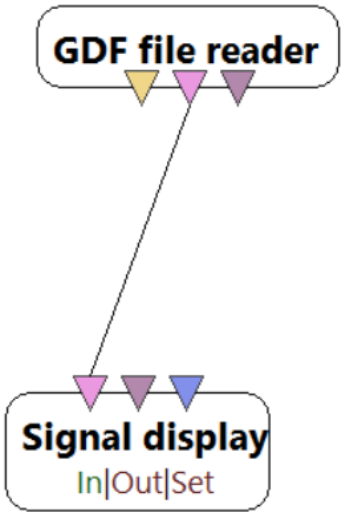
Exercise 1

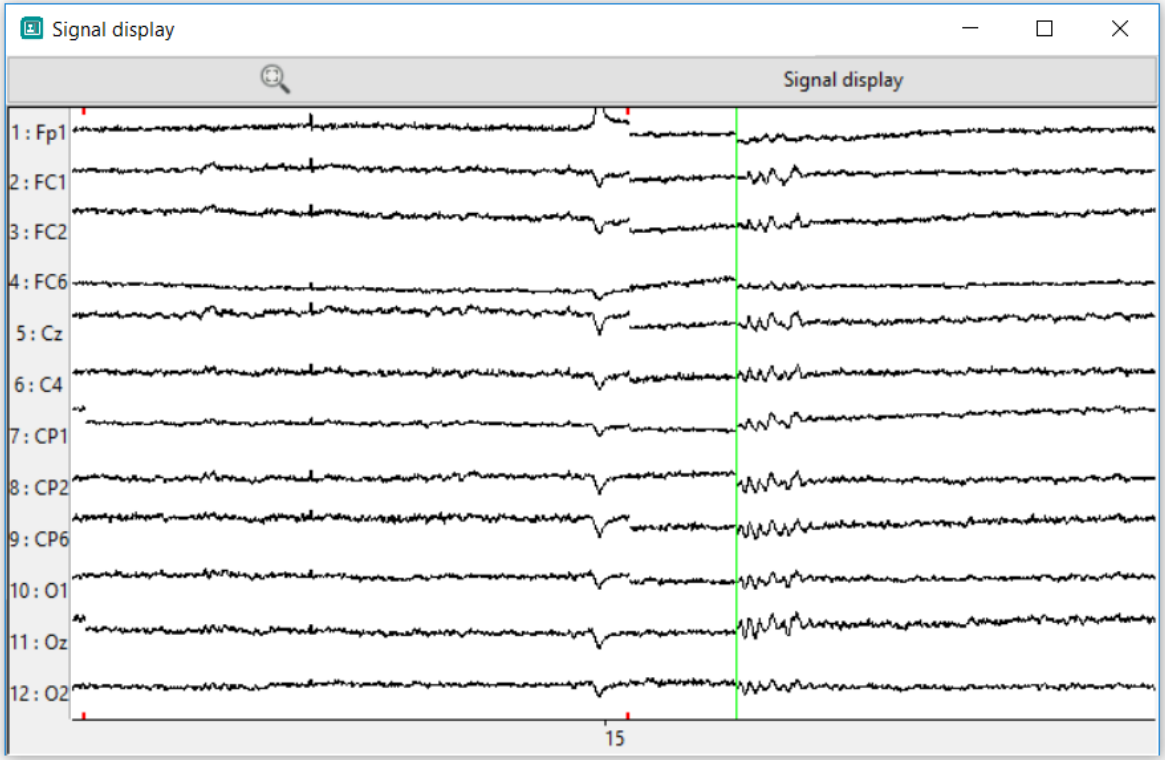
- Offline version – with file reading



- Selecting an EEG file
  - Double click on the box
  - Select file “leftHandMovements.gdf” available on the tutorial page http://openvibe.inria.fr/openvibe-tutorial-nec22/

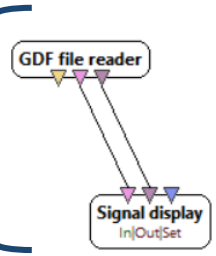
- Press “play”

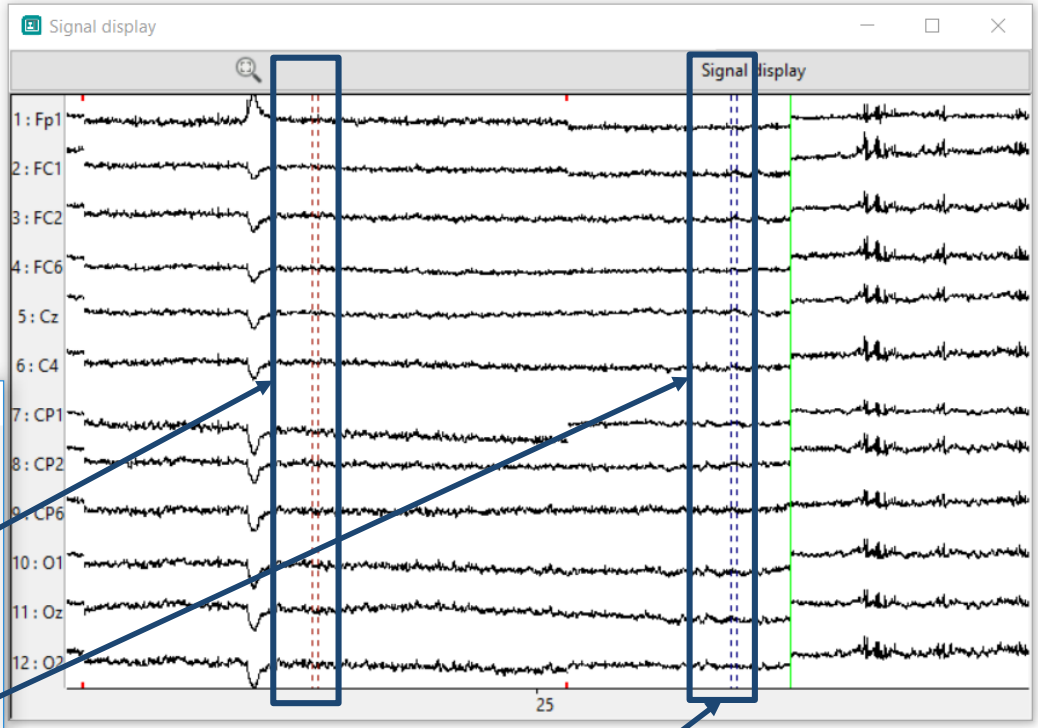

GDF file reader
Signal display
In|Out|Set

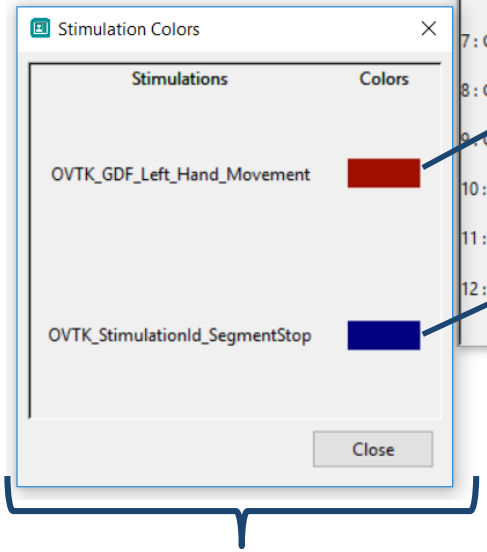

Signal display
Signal display
1 : Fp1
2 : FC1
3 : FC2
4 : FC6
5 : Cz
6 : C4
7 : CP1
8 : CP2
9 : CP6
10 : O1
11 : Oz
12 : O2
15

Visualizing events (a.k.a Stimulations)

To do: connect the « stimulations » input/output (purple)







The stimulations (events) are displayed as doted lines

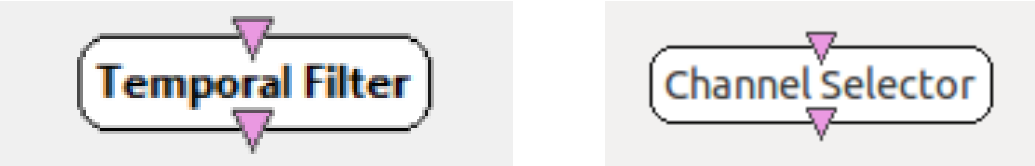
Stimulations colors and names

(click on « signal display » then on « stimulation colors »)

Exercise 2

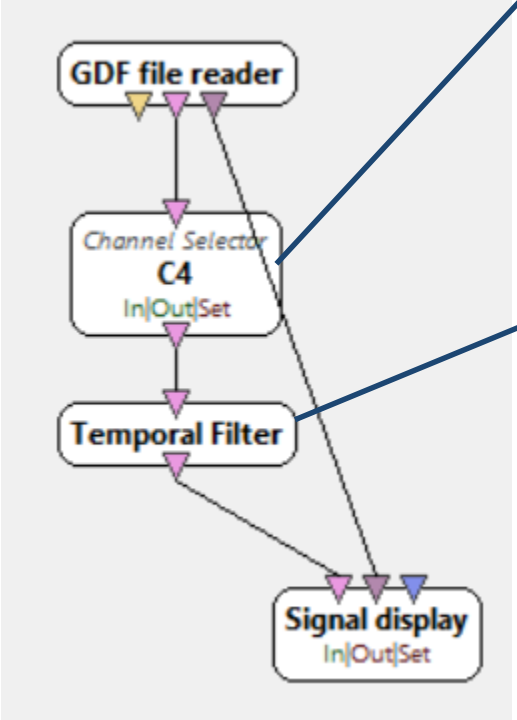
Visualizing sensorimotor rhythms (SMR)

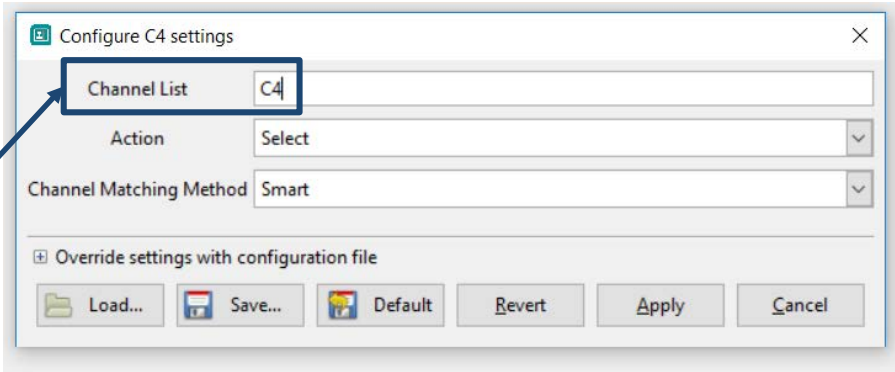
- Need to select the SMR-related channels (e.g., C4)
- Need to band-pass filter the signals in the SMR (e.g., μ: 7-13 Hz)
- You can do this with the following boxes:

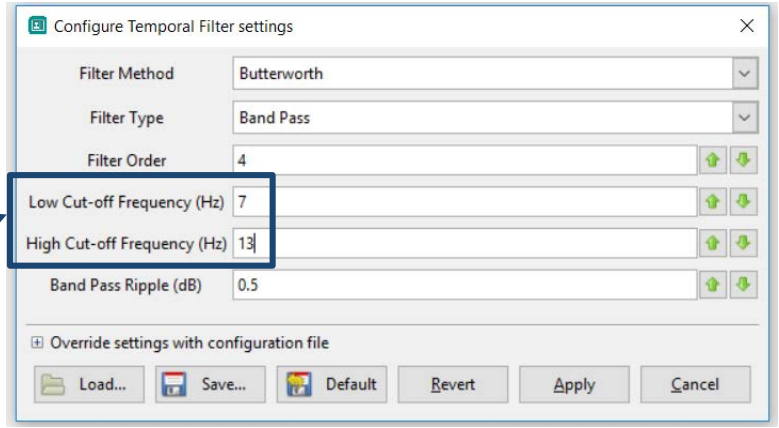


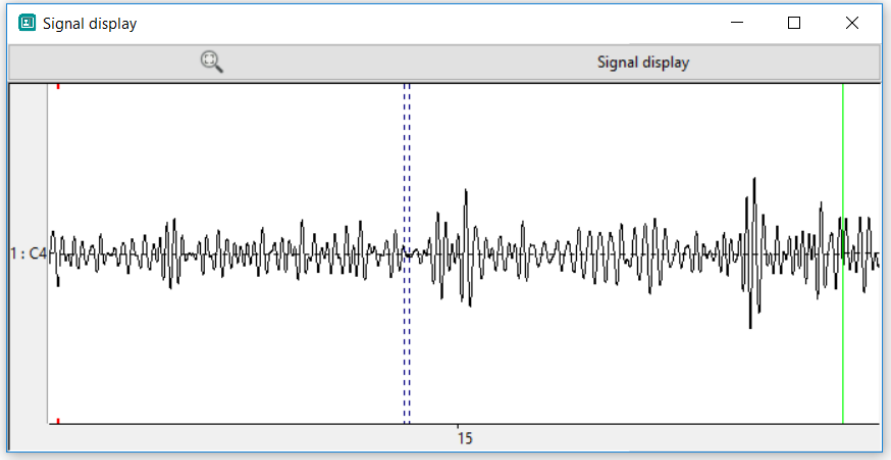
- Notes: you can check http://openvibe.inria.fr for documentation
- The documentation of a box is also available by pressing F1 when the cursor is over the box

Visualizing SMR

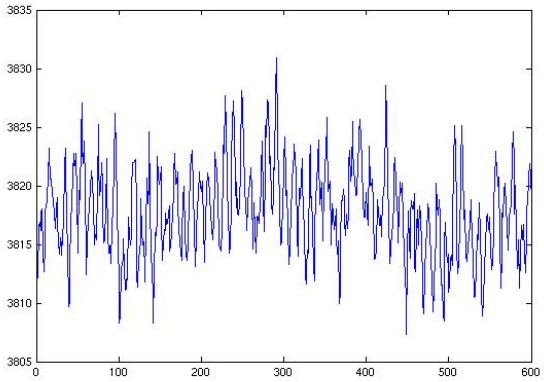






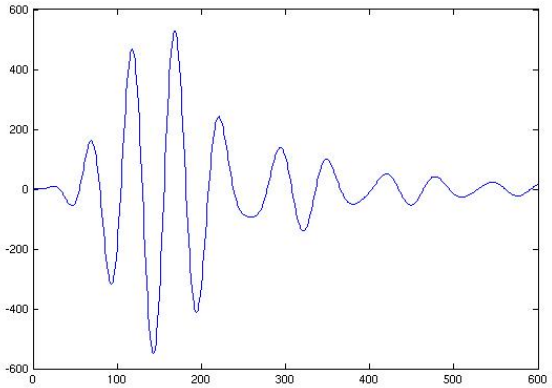


Computing EEG band power

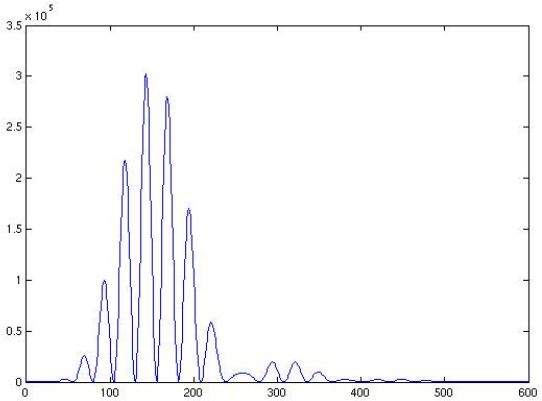


1s of Raw EEG at C3

Band-pass filtering in 8-12 Hz



Power estimation (squaring)

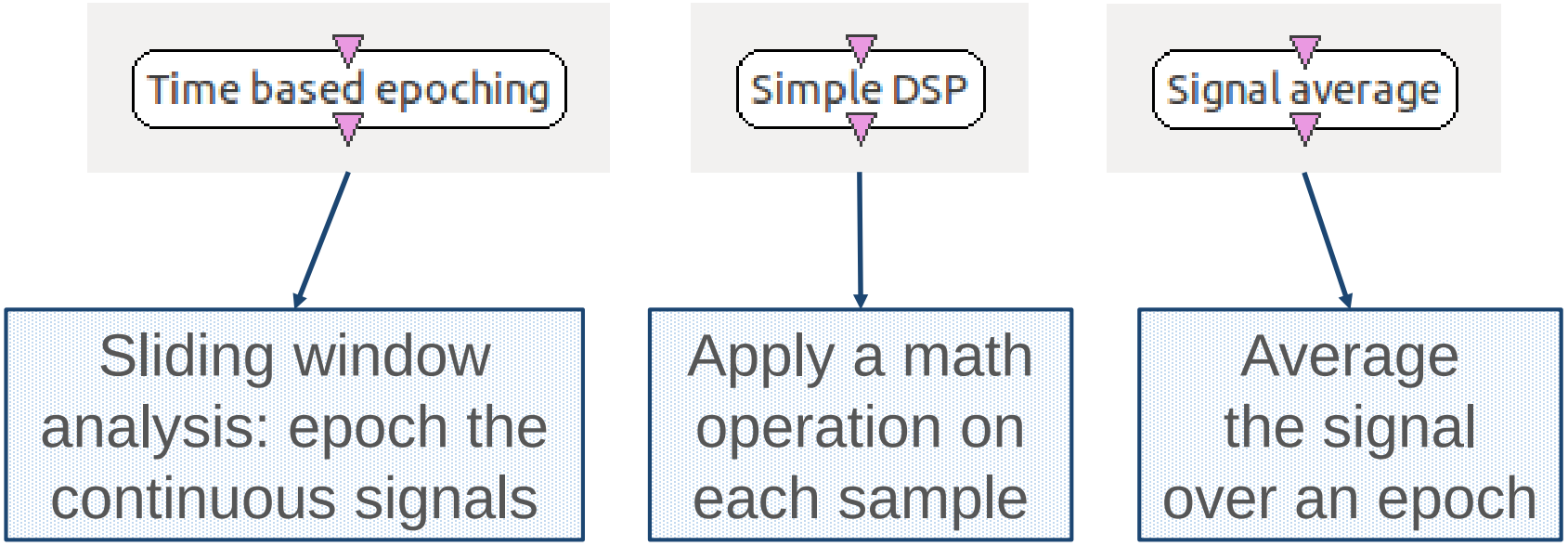


Temporal average

8-12 Hz band power for channel C3

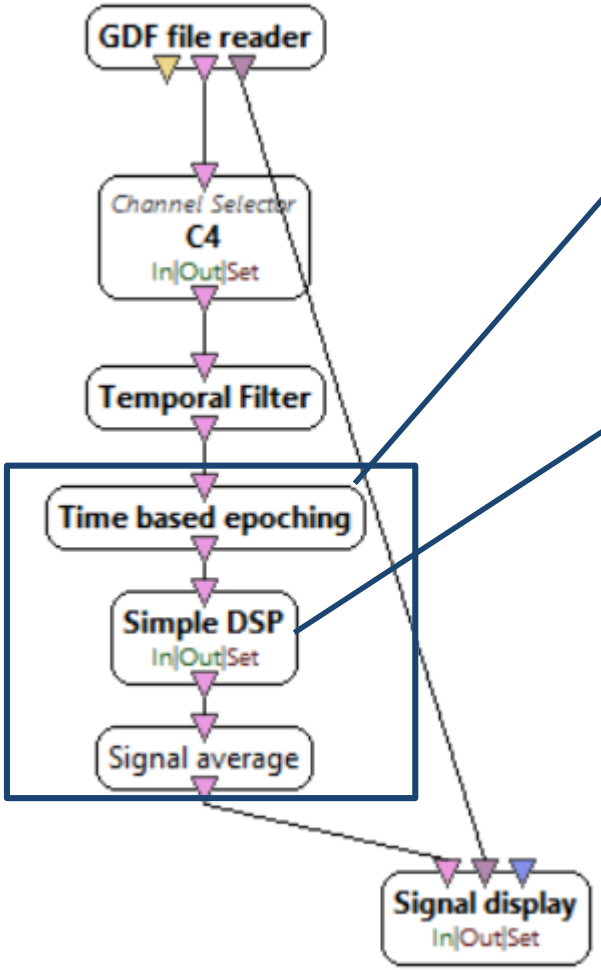
Exercise 3

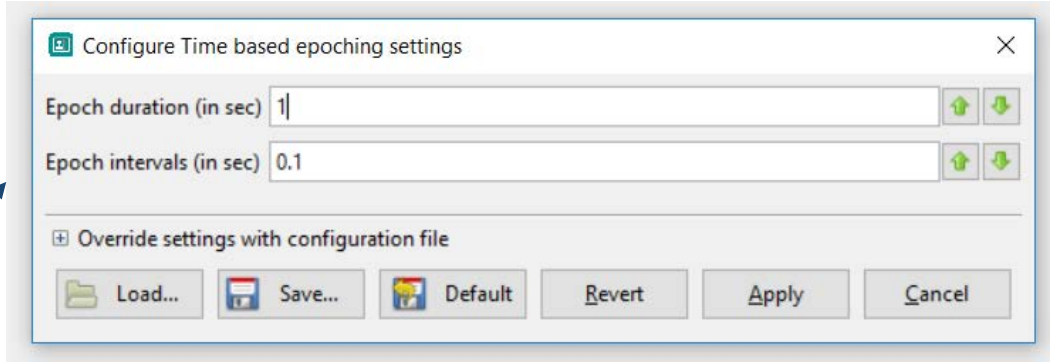
- Compute the SMR band power on 1s long sliding windows

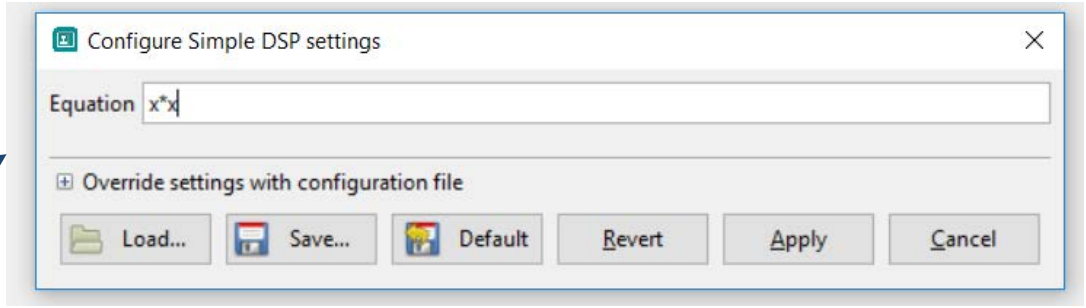


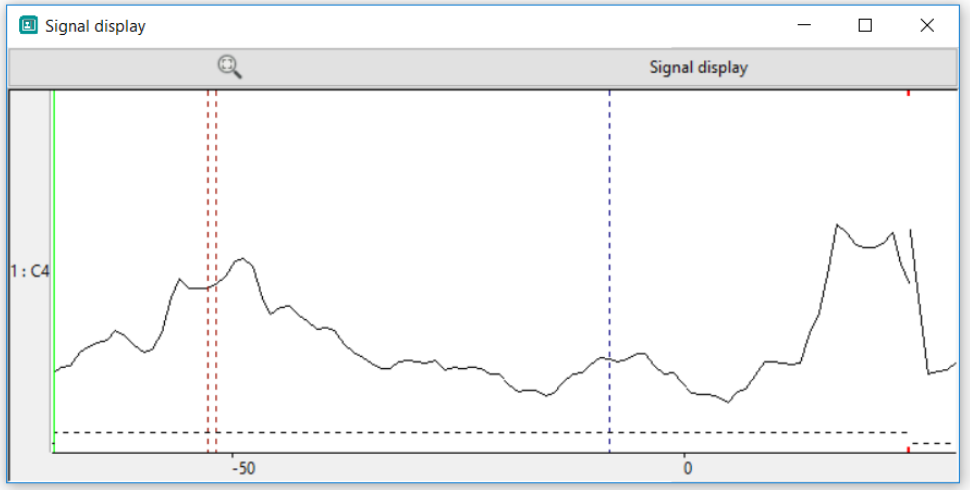
Note: to ease the signal visualization in that case, you can set the « Time Scale » setting of the signal display from 10 to 100

Visualizing Mu band power continuously

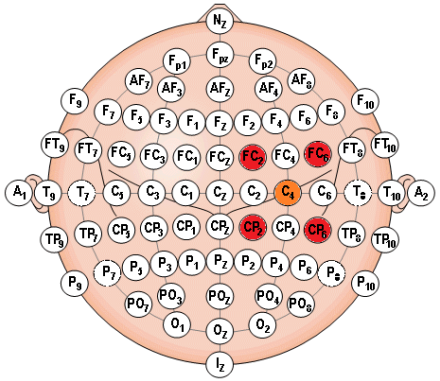




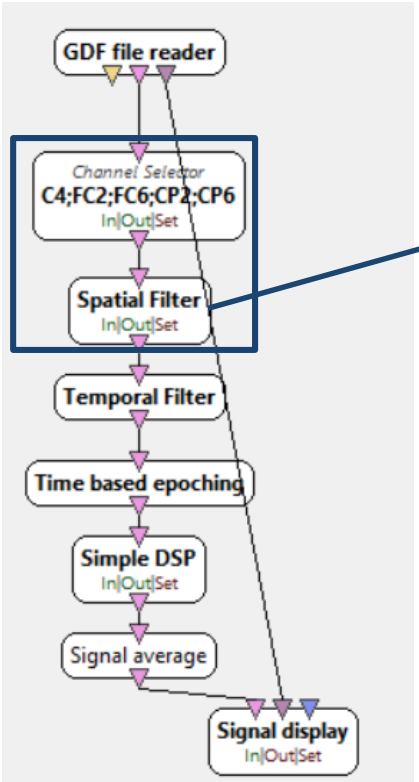


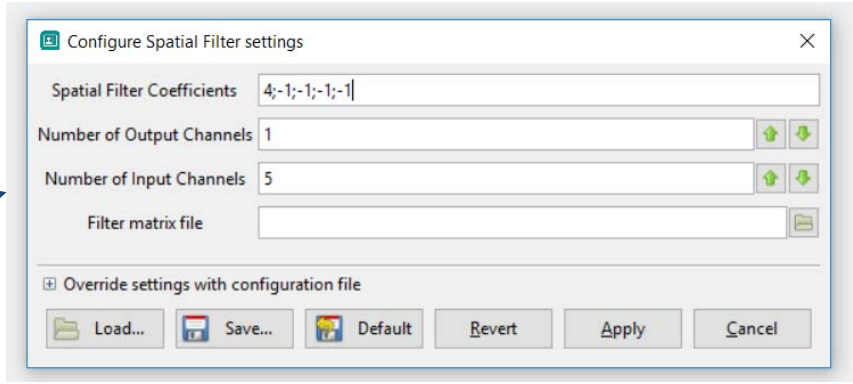


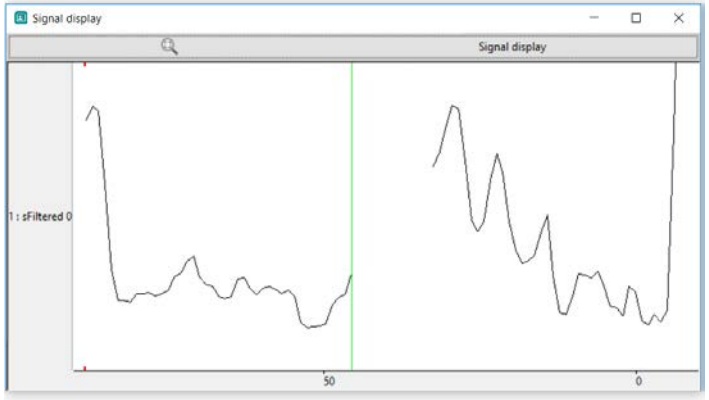
Spatial Filtering



- Ex: Laplacian filters
  - LapC4= 4*C4 – FC2 – FC6 – CP2 – CP6

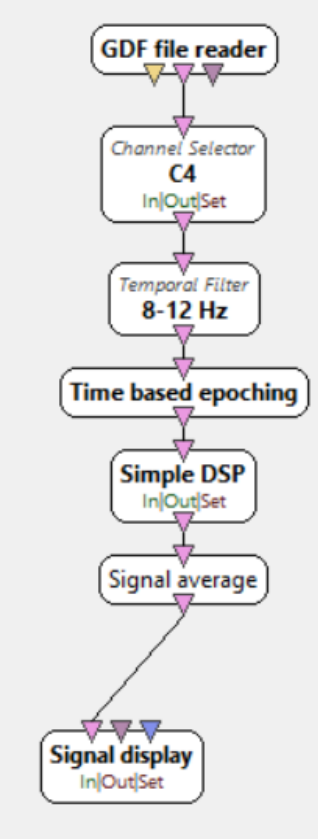


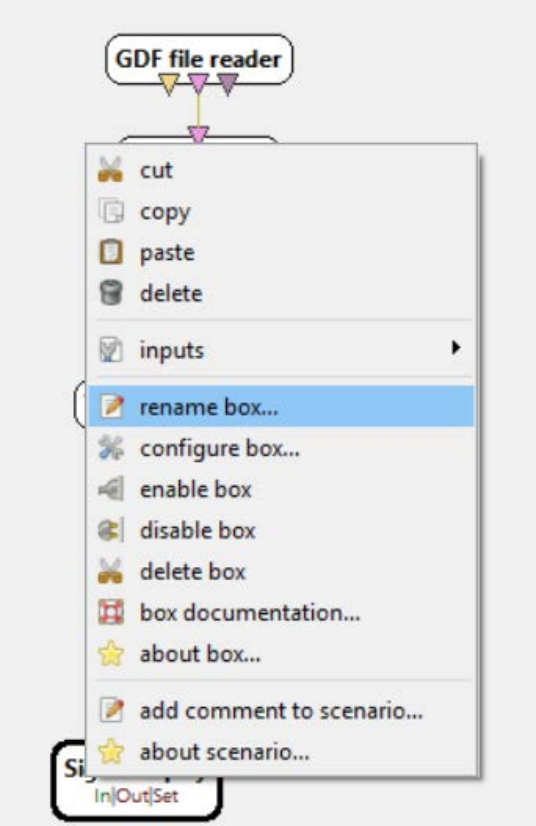


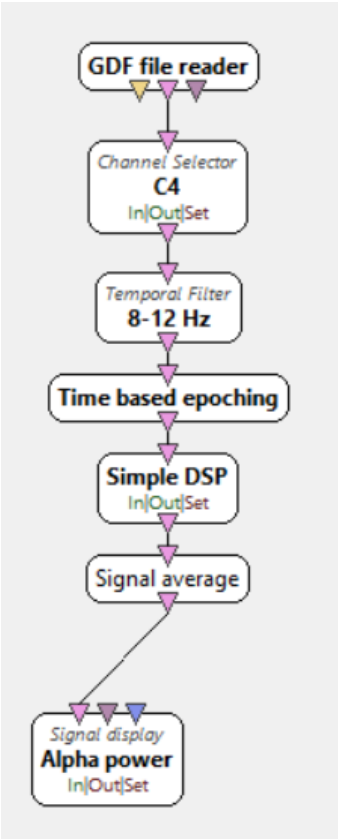


A simple Neurofeedback scenario: Alpha/Theta ratio neurofeedback

- Computing and visualizing alpha power in C4



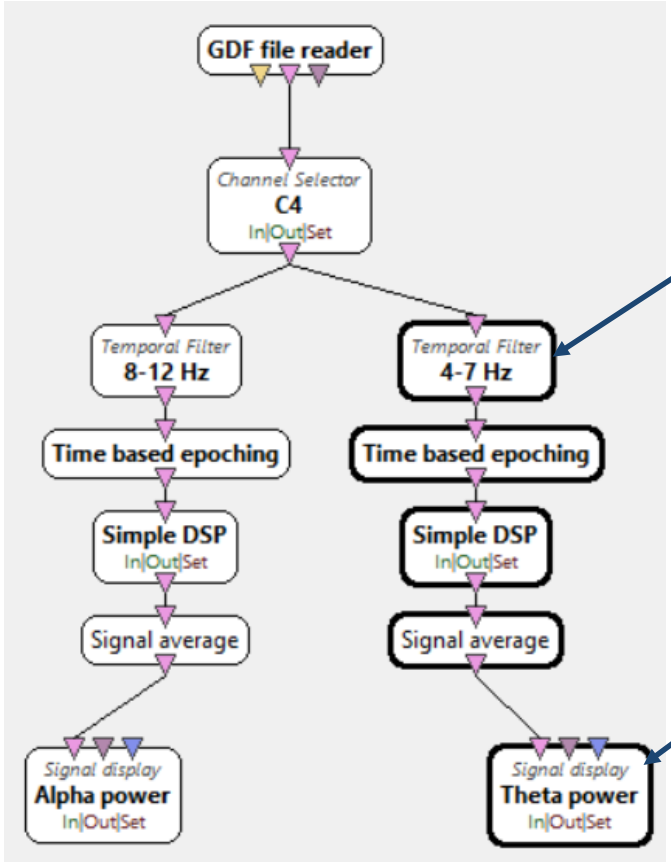




Right click on the signal display >> rename box… >> name it “Alpha power”

A simple Neurofeedback scenario: Alpha/Theta ratio neurofeedback

- Adding the theta power to the scenario

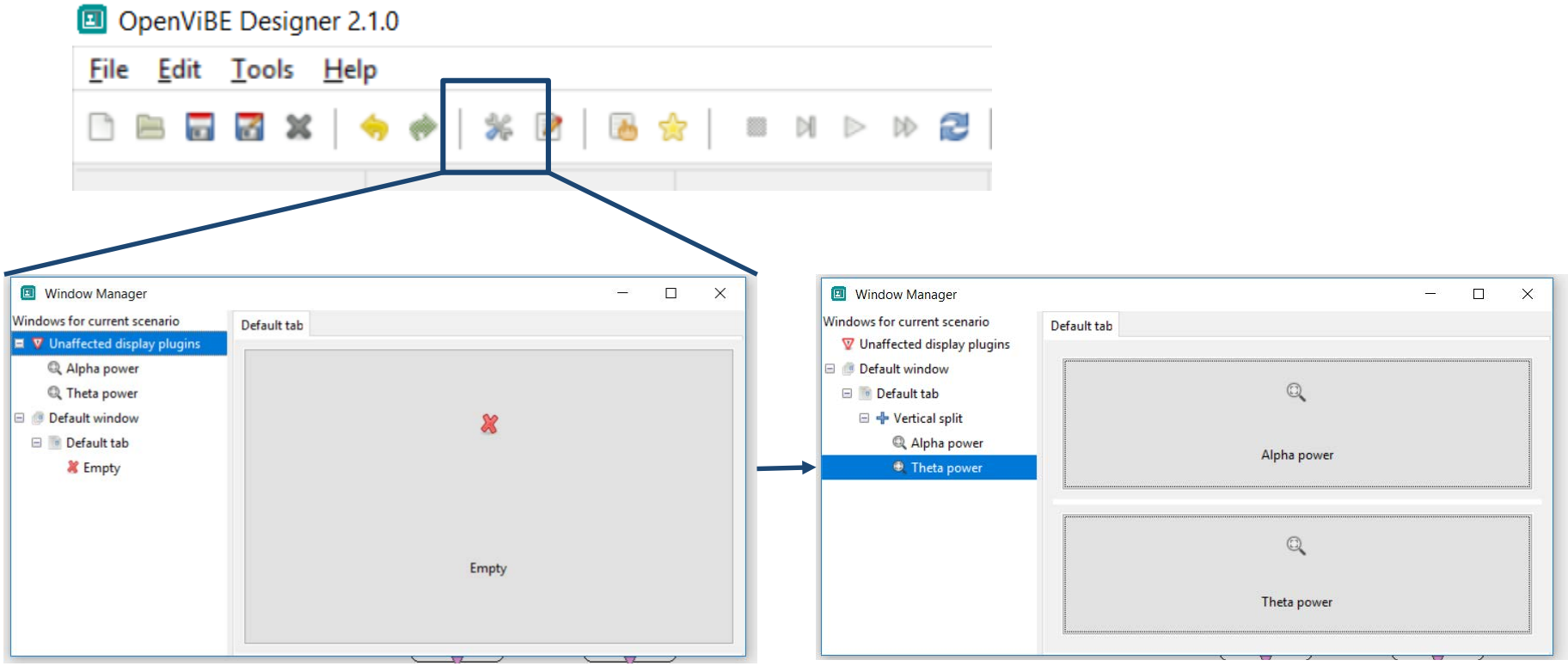


1 - Copy-paste this set of boxes

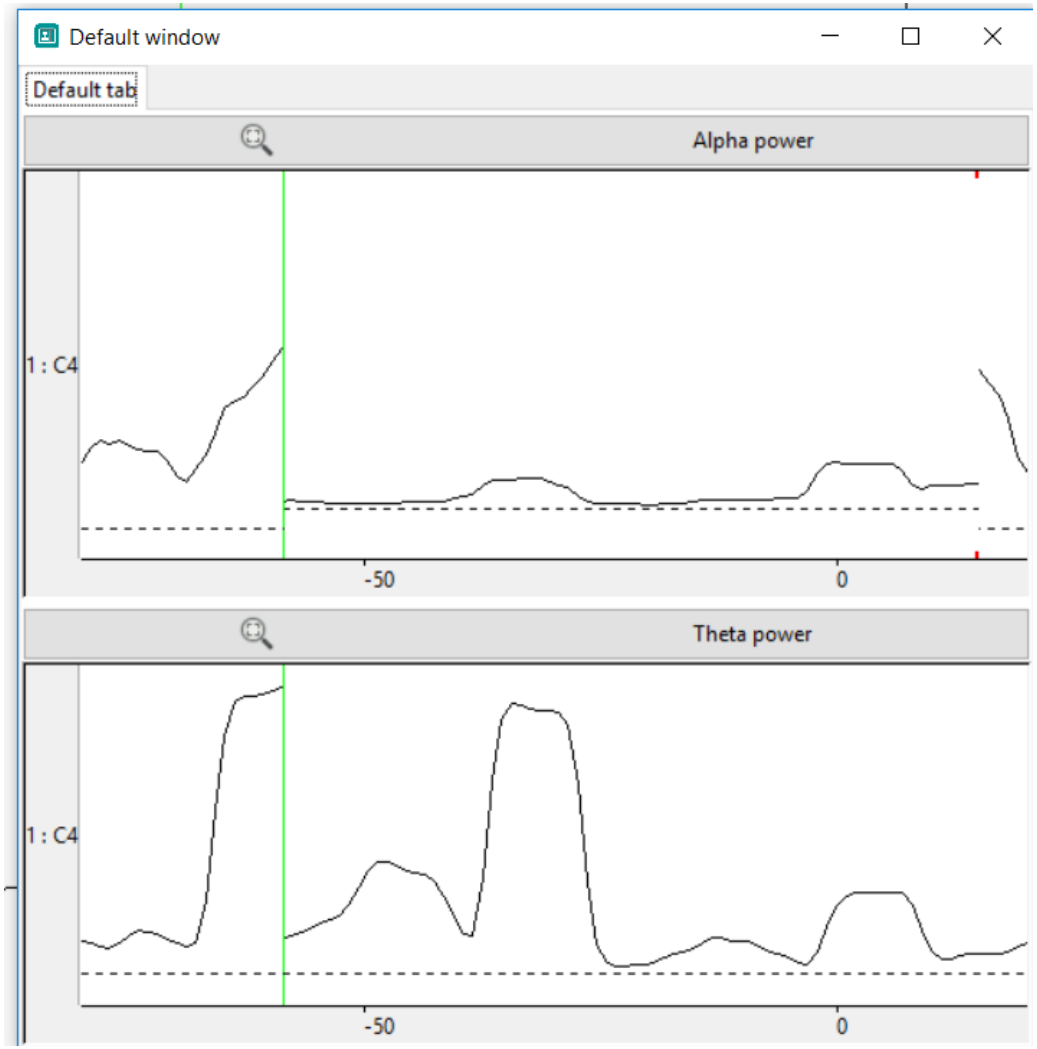
2 - Change the frequency range (4-7 Hz)

3 – Rename the display

The Window Manager

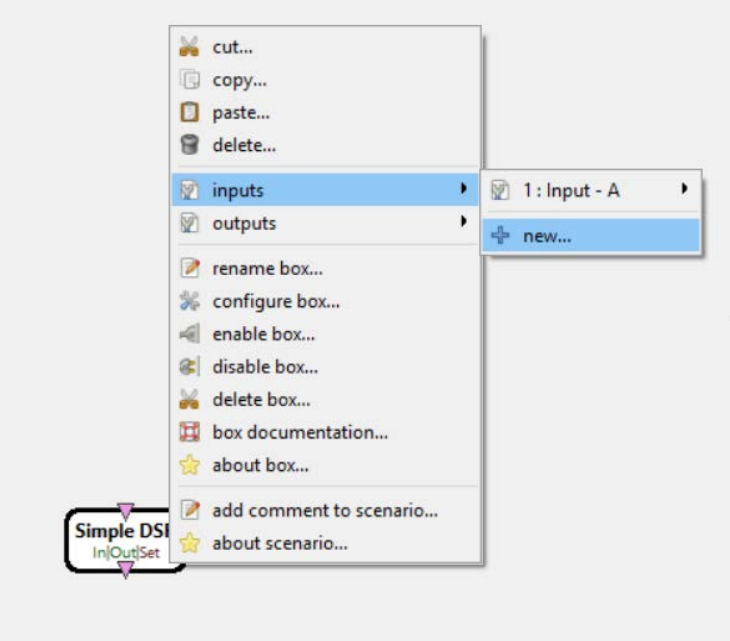


The Window Manager

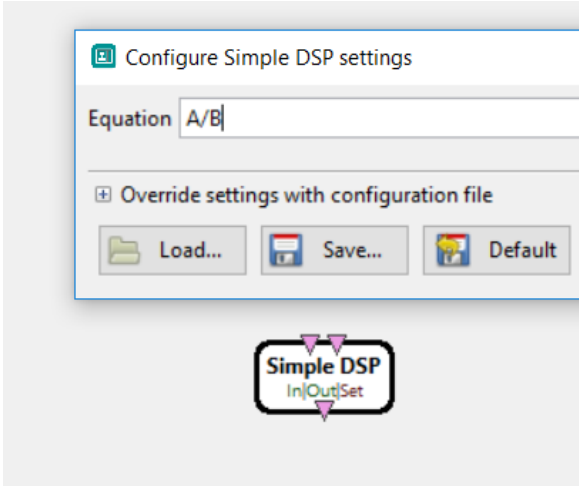


A simple Neurofeedback scenario: Alpha/Theta ratio neurofeedback

- Computing the alpha over theta ratio



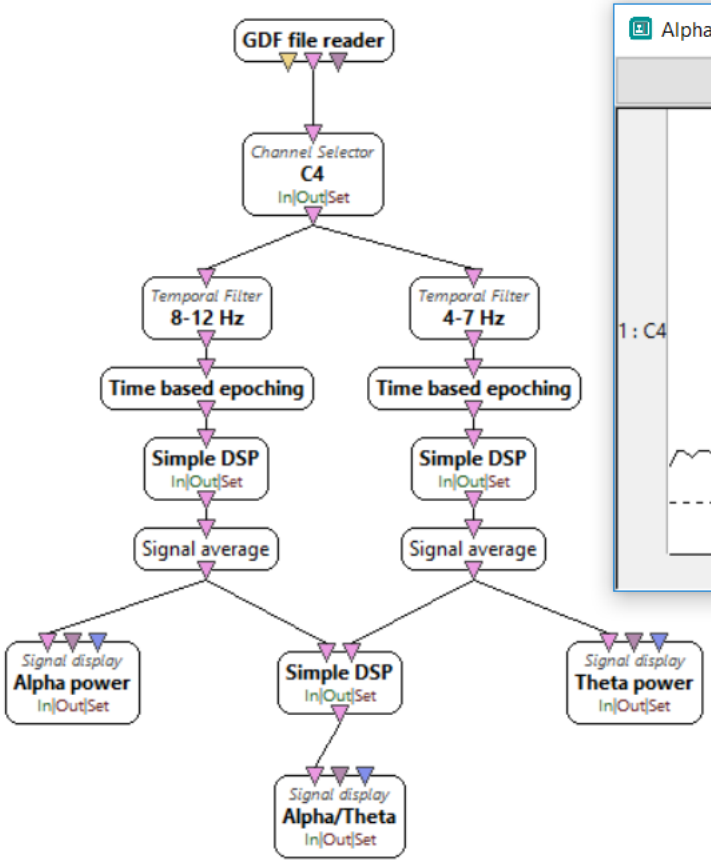
Add a “SimpleDSP”, and right click on it to add an input

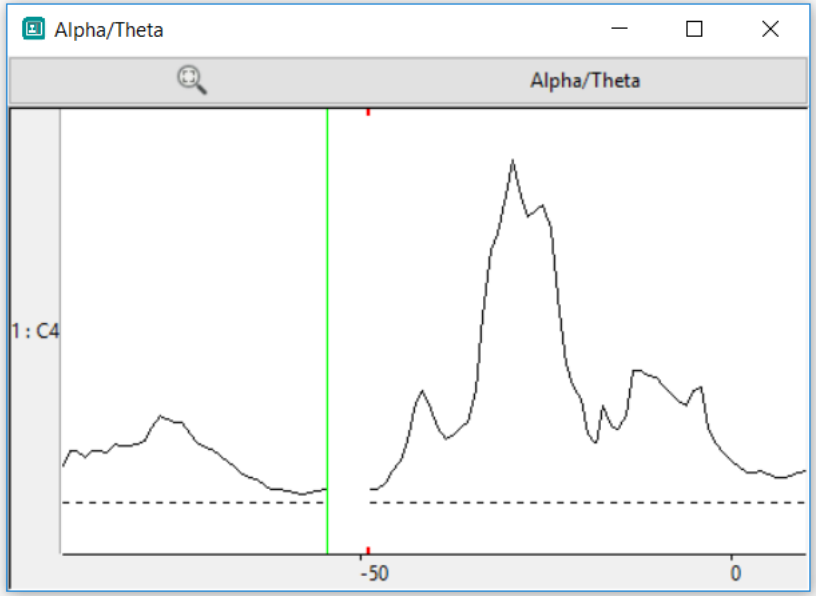


Use the “A/B” formula
(ratio of first input over second input)

A simple Neurofeedback scenario: Alpha/Theta ratio neurofeedback

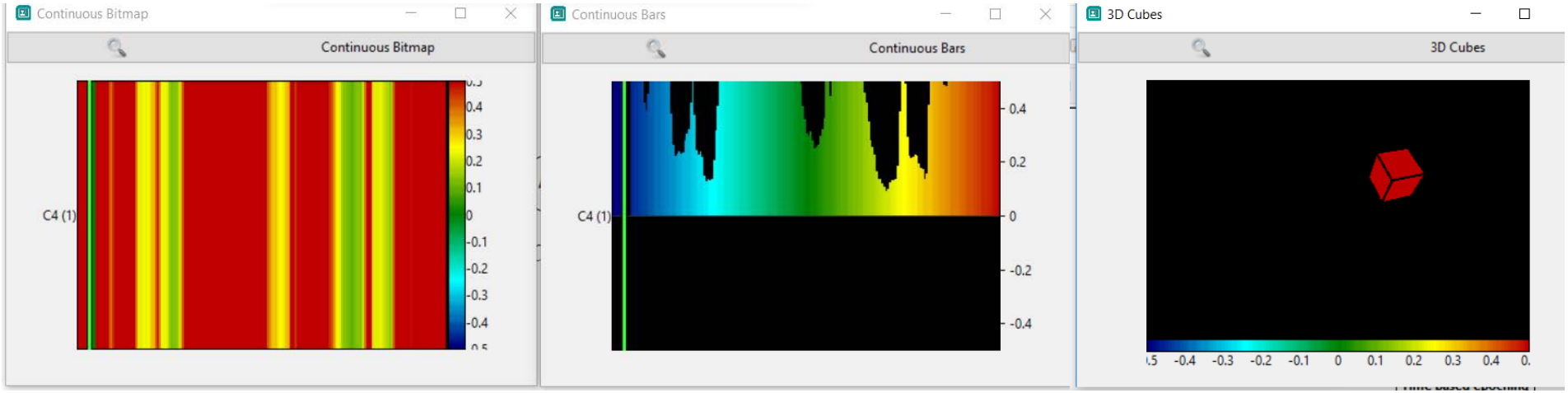
- Plug-in the simple DSP box and visualize the result!





A simple Neurofeedback scenario: Alpha/Theta ratio neurofeedback

You can add « fancy » visualizations, see « advanced visualization » boxes

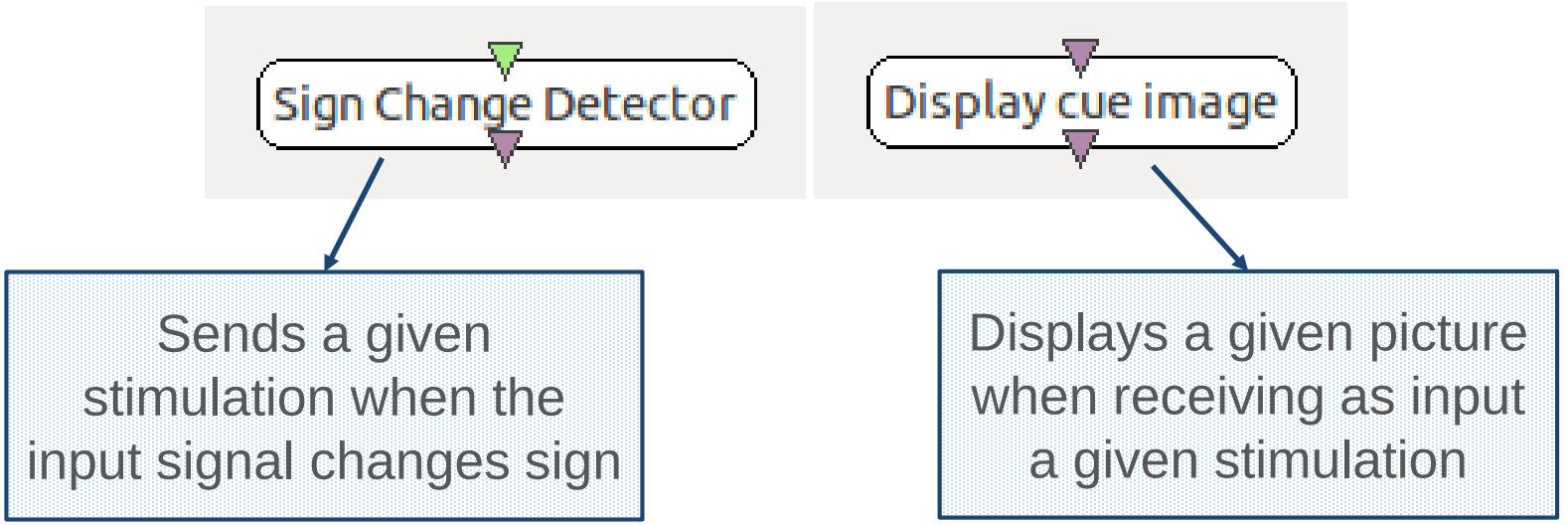


Exercise 4: Neurofeedback reward

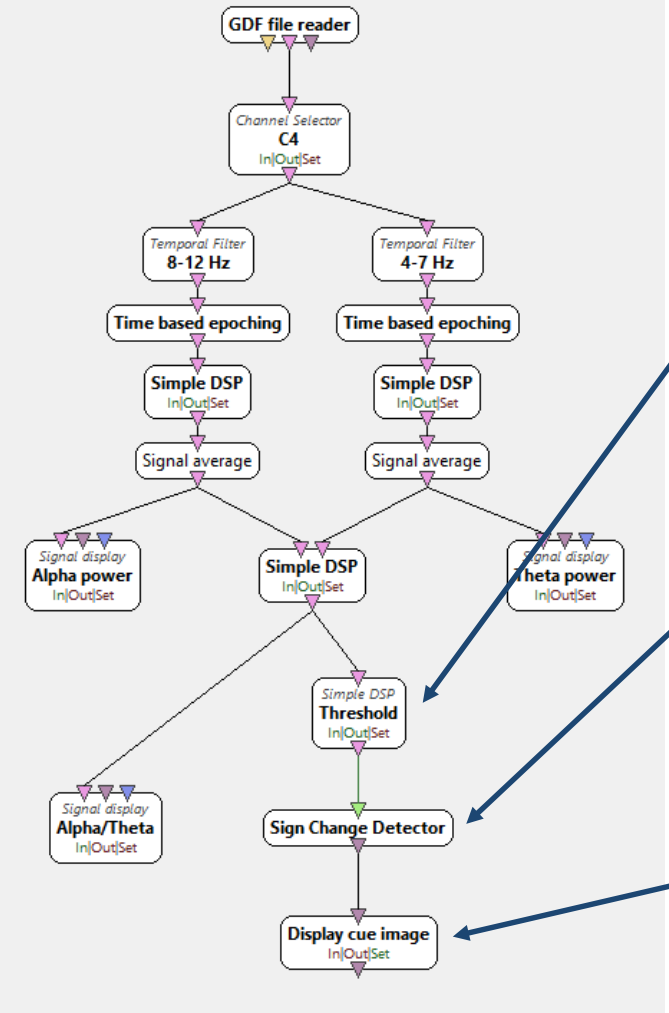
Automatically display a reward picture when the users' alpha/theta ratio crosses a given threshold!

You will need the following two boxes:

(and to define your threshold value)



Neurofeedback reward scenario



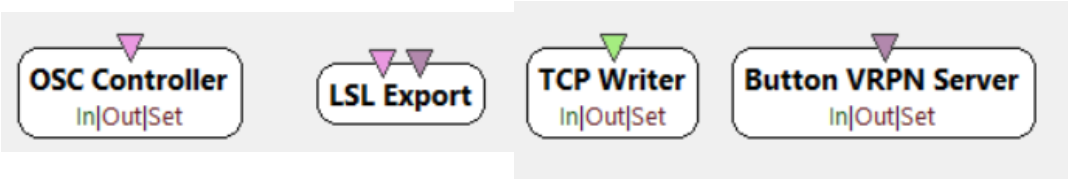
1 – Subtracts the threshold value

2 – Defines (box settings) the (reward) stimulation to send when the threshold is crossed

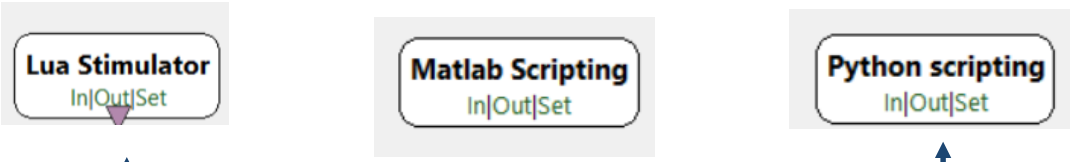
3 – Defines (box settings) the image to display when receiving the reward stimulation

Going Further - in brief

- Communication with other software/applications



- Rapid prototyping



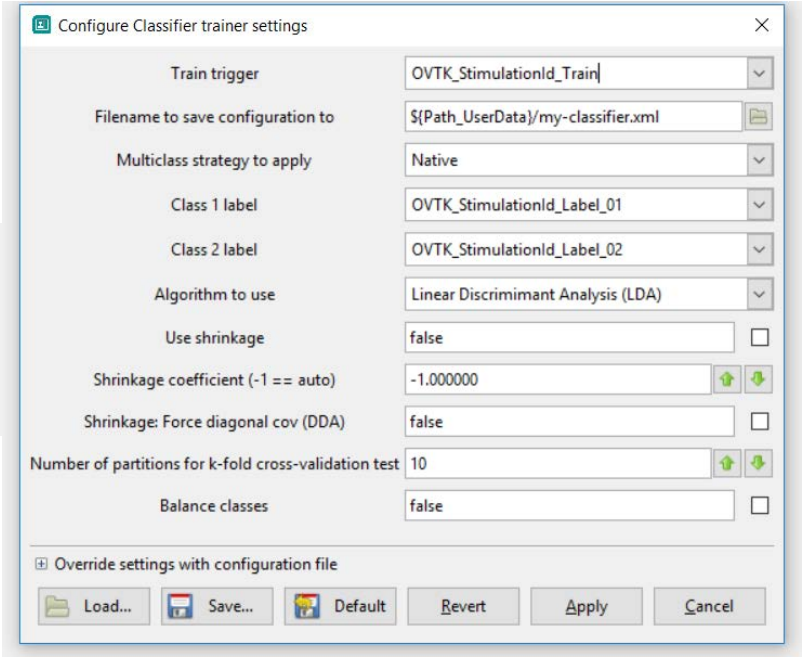
Designing protocols with Lua in OpenViBE by Laurent Bougrain

Quick prototyping in OpenViBE in Python by Thomas Prampart

Machine Learning in OpenViBE in brief

- Using machine learning
  - various classifiers: LDA, sLDA, SVM, Neural Network, Riemannian geometry classifiers (MDM, fgMDM, TSC, etc), etc.
  - various data-driven spatial filters (CSP, RCSP, XDAWN, etc.)

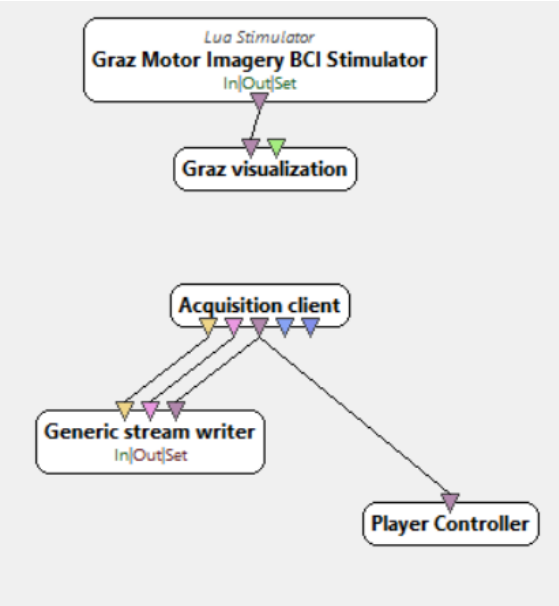
Calibration (training)



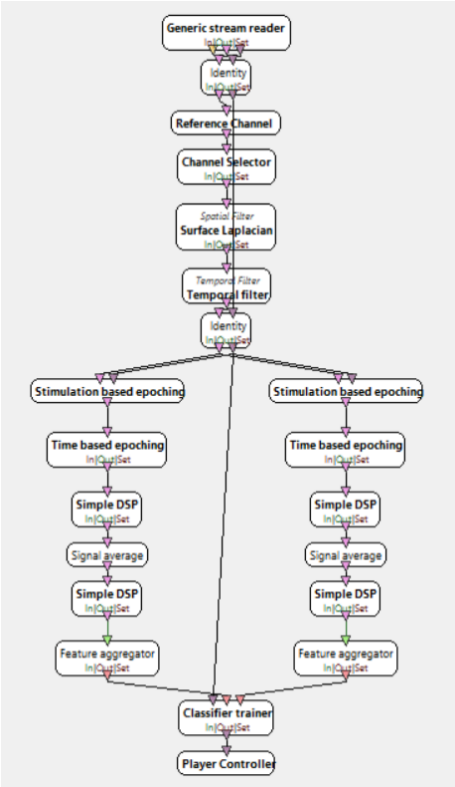
Use (testing)

Machine Learning in OpenViBE in brief

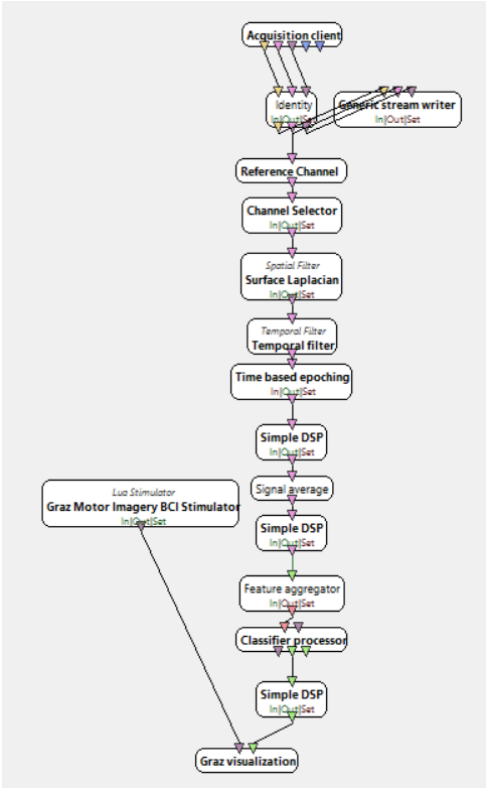
- Typically: several scenarios when using machine learning



1 - Training data acquisition scenario



2- Classifier training scenario

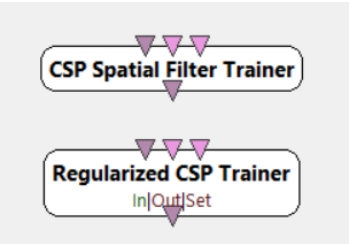


3 - Online feedback scenario

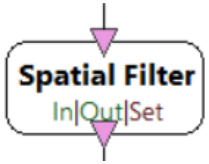
Machine Learning in OpenViBE in brief

- Similar principle for spatial filters

Calibration (training)



Use (testing)



Hands-on
Machine Learning in
OpenViBE
by Laurent Bougrain

Thank you for your attention !

Any question?

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