

# fNIRS訊號處理 - Homer3

教育訓練工作坊

[http://cflu.lab.nycu.edu.tw/CFLu\\_course\\_fnirsWorkshop.html](http://cflu.lab.nycu.edu.tw/CFLu_course_fnirsWorkshop.html)

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# Please download...

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- Handouts

[http://cflu.lab.nycu.edu.tw/fNIRSWorkshop\\_Homer3Ana\\_CFLu.pdf](http://cflu.lab.nycu.edu.tw/fNIRSWorkshop_Homer3Ana_CFLu.pdf)

- Homer3 v1.33 (fixed version)

[http://cflu.lab.nycu.edu.tw/Homer3\\_v1\\_33.zip](http://cflu.lab.nycu.edu.tw/Homer3_v1_33.zip)

- Demo materials

<http://cflu.lab.nycu.edu.tw/2022NYCUfNIRS.zip>

# HOMER & ATLASVIEWER

<https://github.com/BUNPC/Homer3/releases/tag/v1.33.0>

**Homer3** and **AtlasViewer** are MATLAB applications that provide an open-source platform for the analysis and display of fNIRS data.

Homer3 is the latest installment in the HOMER software series. It builds upon Homer2 by enabling custom processing scripts at subject and group levels. This will enable more powerful statistical analyses of these results. Homer3 also implements the **Shared NIR Data Format (SNIRF)** that has been developed and adopted by a broad consortium of software and hardware developers.

*Huppert, T., Diamond, S., Franceschini, M., Boas, D. (2009). HomER: a review of time-series analysis methods for near-infrared spectroscopy of the brain.*

**BU** College of Engineering

David Boas, Ph.D.



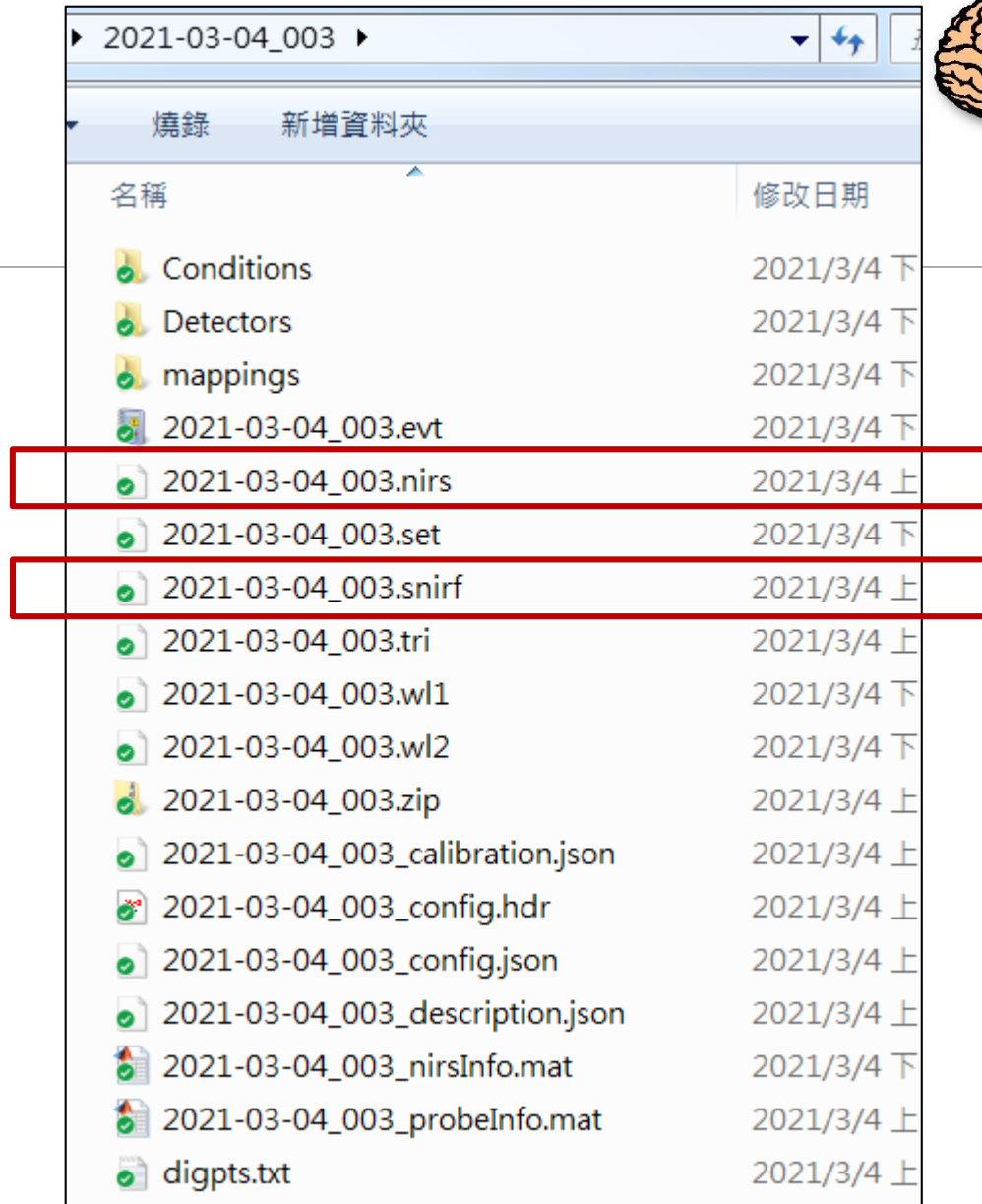
Professor (BME, ECE)  
Director of Neurophotonics  
Center

# Demo data

Recorded by NIRx NIRSport2 model.

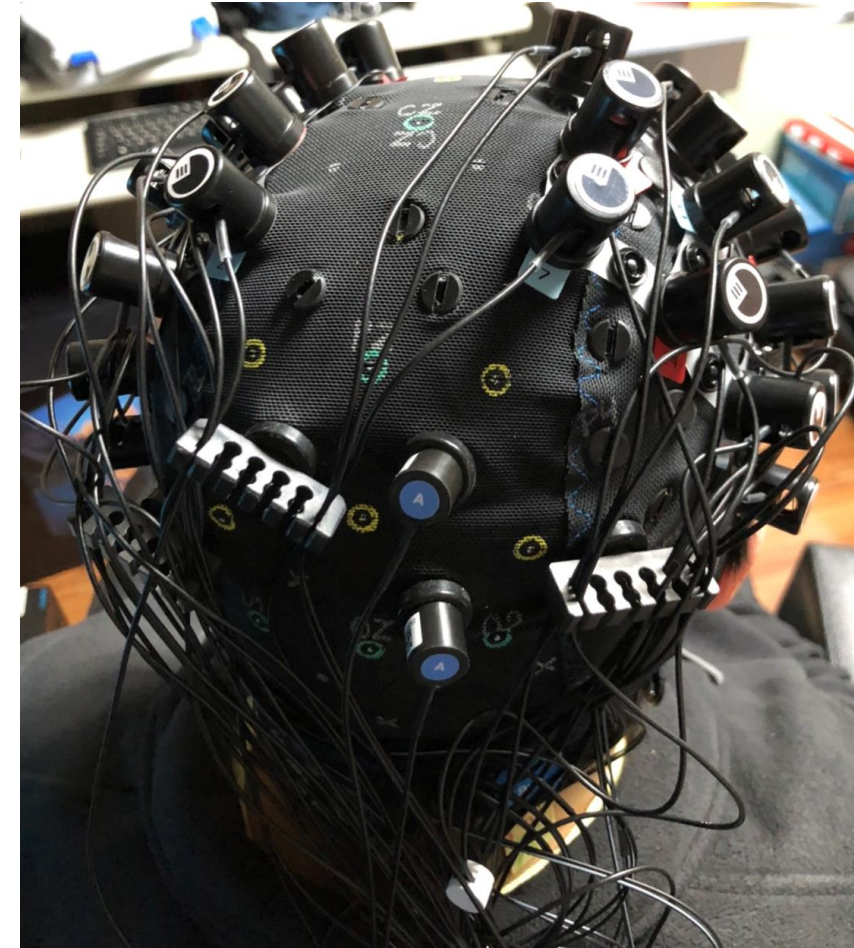
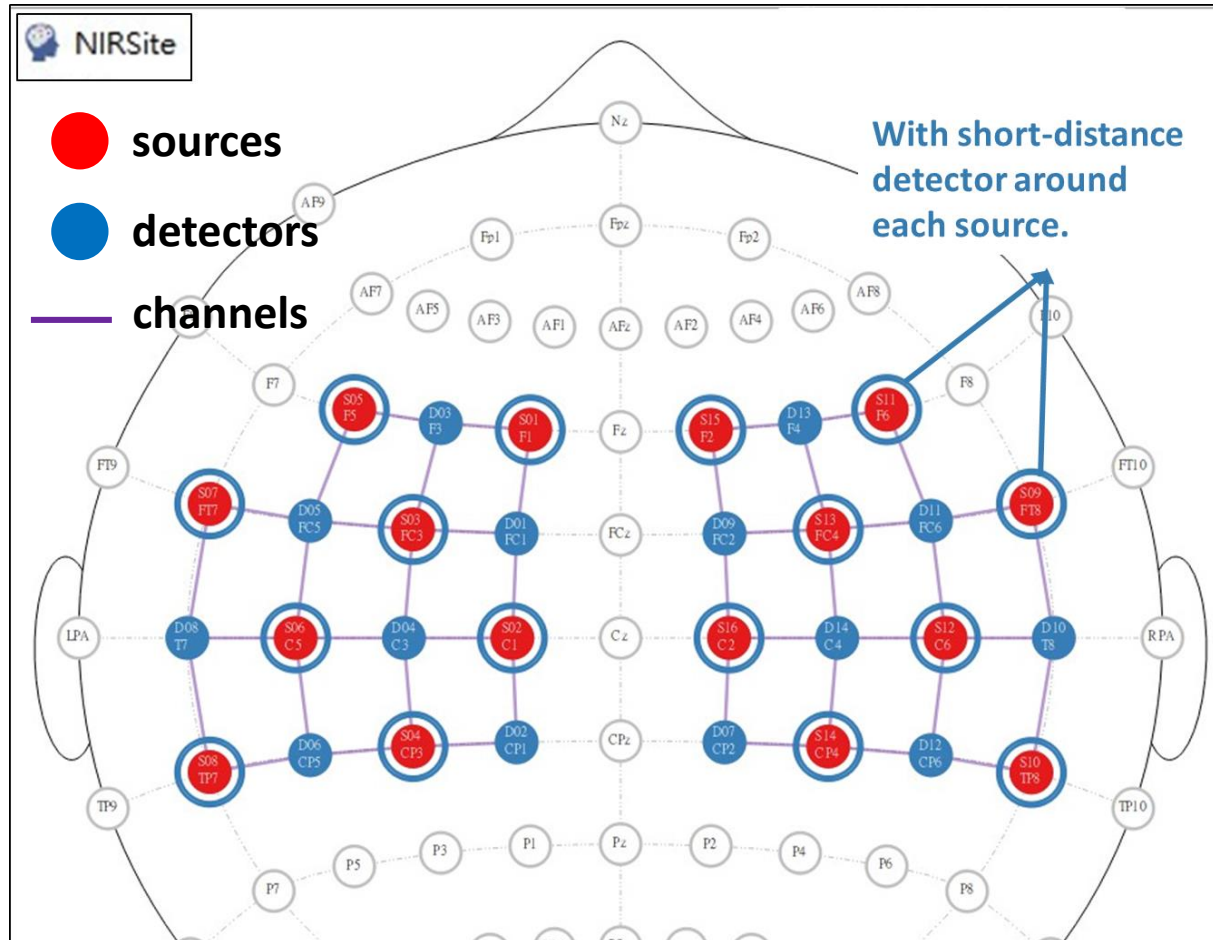
Homer2 fNIRS data format (\*.nirs, old)

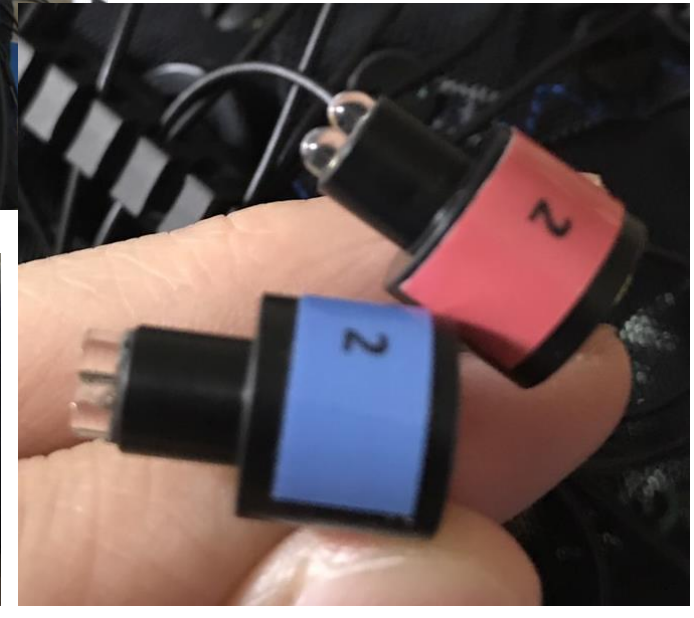
Homer3 fNIRS data format (\*.snirf, new)



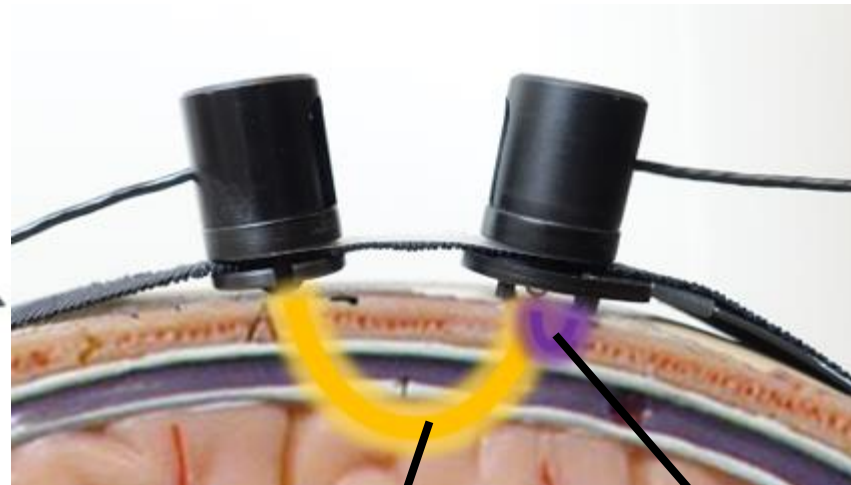
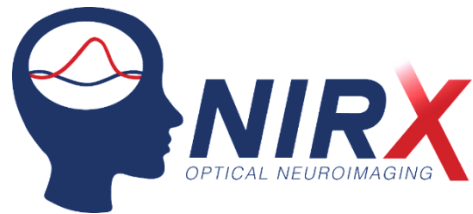
名稱	修改日期
Conditions	2021/3/4 下
Detectors	2021/3/4 下
mappings	2021/3/4 下
2021-03-04_003.evt	2021/3/4 下
2021-03-04_003.nirs	2021/3/4 上
2021-03-04_003.set	2021/3/4 下
2021-03-04_003.snirf	2021/3/4 上
2021-03-04_003.tri	2021/3/4 上
2021-03-04_003.wl1	2021/3/4 下
2021-03-04_003.wl2	2021/3/4 下
2021-03-04_003.zip	2021/3/4 上
2021-03-04_003_calibration.json	2021/3/4 上
2021-03-04_003_config.hdr	2021/3/4 上
2021-03-04_003_config.json	2021/3/4 上
2021-03-04_003_description.json	2021/3/4 上
2021-03-04_003_nirsInfo.mat	2021/3/4 下
2021-03-04_003_probeInfo.mat	2021/3/4 上
digpts.txt	2021/3/4 上

# Source-Detector (SD) Layout





# Short-Distance Detector (SDD) Setup

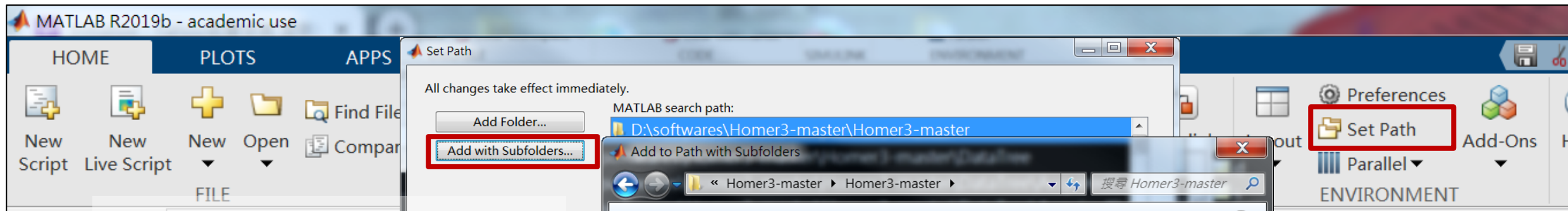


Mainly from cortex  
With partly coverage of scalp

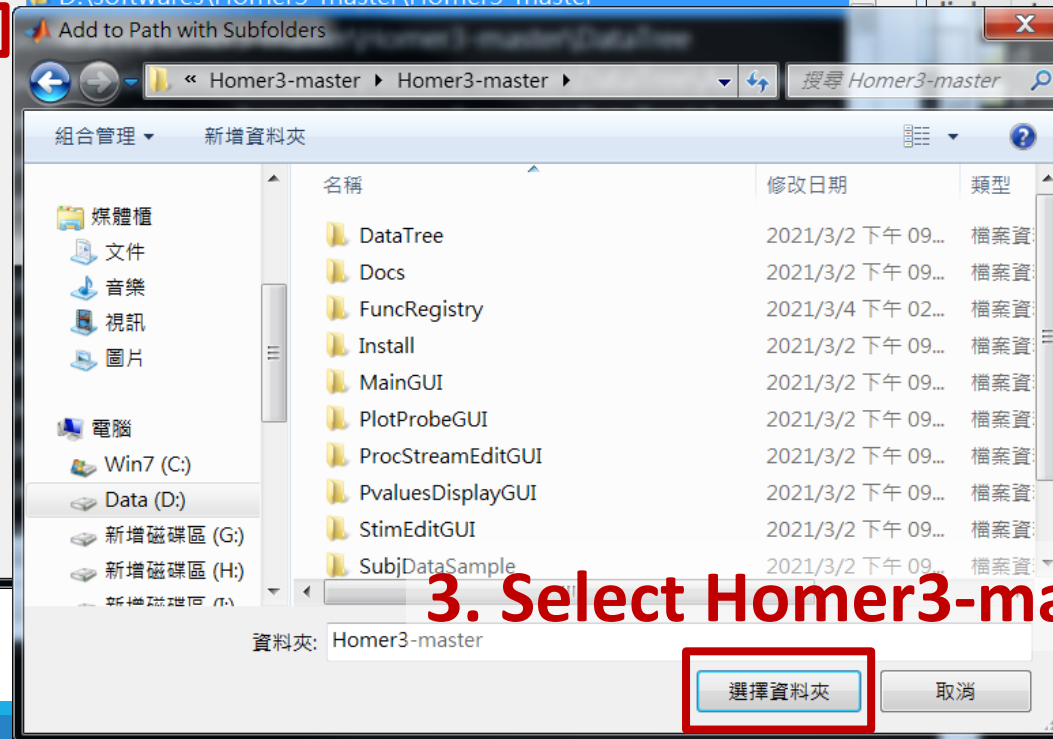
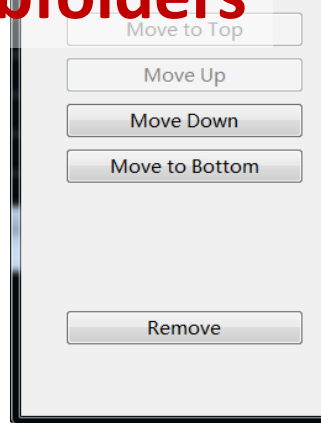
SDD: Mainly from scalp

# Install Homer3

## 1. Set Path



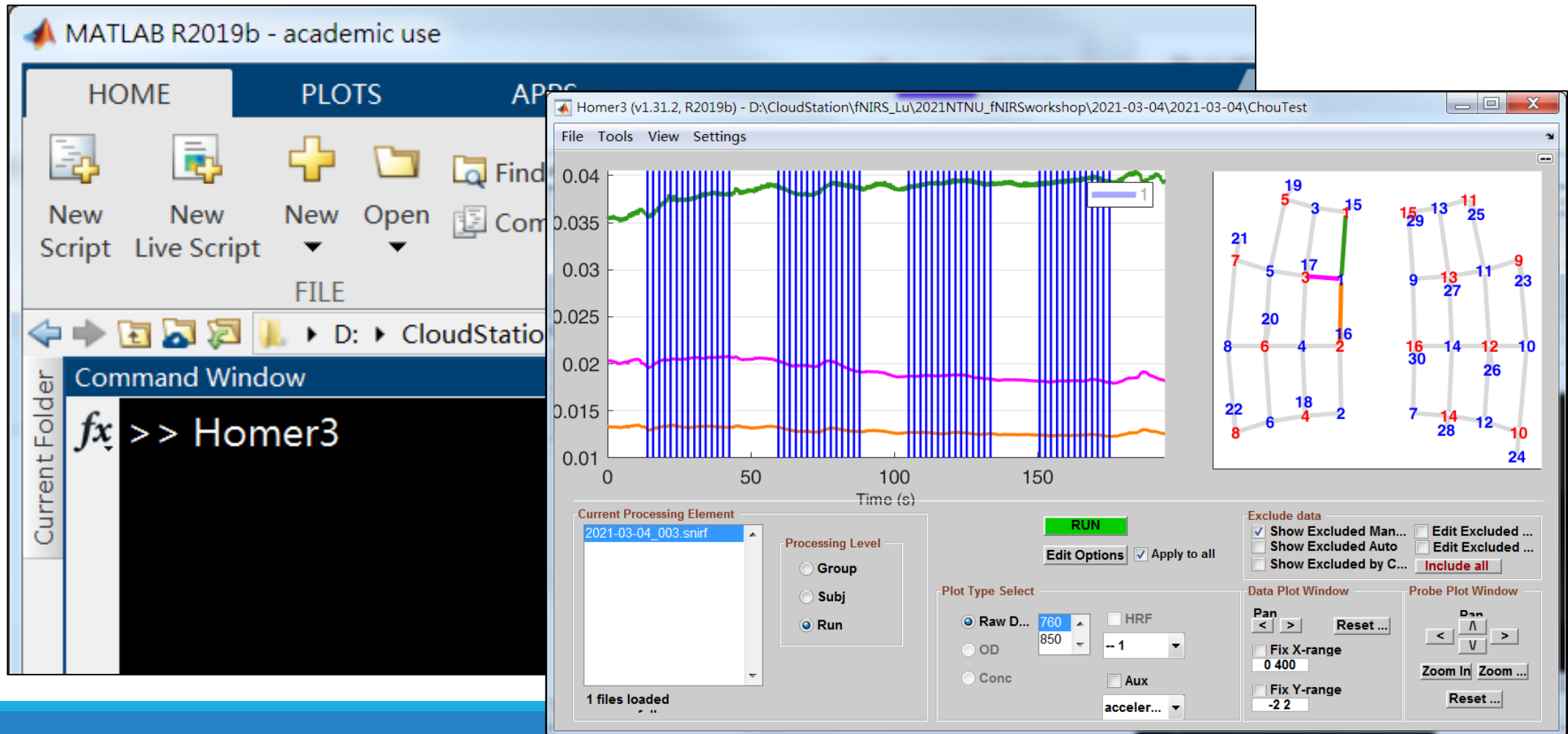
## 2. Add with Subfolders



## 3. Select Homer3-master root folder

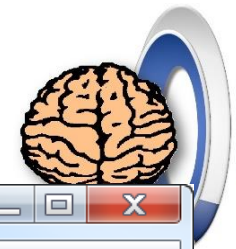


# Initialize Homer3



The screenshot shows the MATLAB R2019b environment. The Command Window displays the command `fx >> Homer3`. The Homer3 window (v1.31.2, R2019b) is open, showing a time-series plot of three channels (green, pink, orange) over time (0 to 150+ seconds). The plot includes vertical blue lines indicating task periods. To the right of the plot is a network graph with 30 nodes, each labeled with a number (1-30). The Homer3 window also features a 'Current Processing Element' list with '2021-03-04\_003.snirf' selected, a 'Processing Level' section with 'Run' selected, and various control buttons like 'RUN', 'Edit Options', and 'Apply to all'. The 'Exclude data' section has 'Show Excluded Man...' and 'Show Excluded Auto' checked. The 'Data Plot Window' and 'Probe Plot Window' sections have 'Fix X-range' and 'Fix Y-range' options.

# Homer3 User Interface



The screenshot shows the Homer3 software interface with several components labeled in red text:

- Processing Setup**: Points to the 'Tools' menu, which includes options like 'Edit Stimulus', 'Edit Processing Stream', 'Plot Probe', 'Display P-Values', 'Display Power Spectrum', 'Downsample SNIRF File', and 'Segment SNIRF File'.
- Data Plot**: Points to the main data plot area, which displays three time-series plots (green, magenta, and orange) over a time range from 0 to 150 seconds. The y-axis ranges from 0.01 to 0.03.
- Probe Plot**: Points to a network graph on the right side of the interface, showing nodes (numbered 1-30) and edges, with some nodes highlighted in red and blue.
- Processing Control**: Points to the 'RUN' button and the 'Processing Level' section, which includes radio buttons for 'Group', 'Subj', and 'Run'.
- File List**: Points to the 'Current Processing Element' list, which shows the file '2021-03-04\_003.snirf'.
- Data Plot Types**: Points to the 'Plot Type Select' section, which includes radio buttons for 'Raw D...', 'OD', and 'Conc', along with numerical input fields and checkboxes for 'HRF', 'Aux', and 'acceler...'.
- Display Control**: Points to the 'Exclude data' and 'Data Plot Window' sections, which include checkboxes for 'Show Excluded Man...', 'Show Excluded Auto', 'Show Excluded by C...', 'Fix X-range', and 'Fix Y-range', along with 'Include all', 'Reset...', 'Zoom In', and 'Zoom ...' buttons.

# ProcStreamEditGUI



Function Library

Employed Function

Function Description

# ProcStreamOptionsGUI

Processing Control

→ Options

Function name

ProcStreamOptionsGUI: (1.31.2) - D:\CloudStation\fnIRS\_Lu\2021NTNU\_fnIRSworkshop...

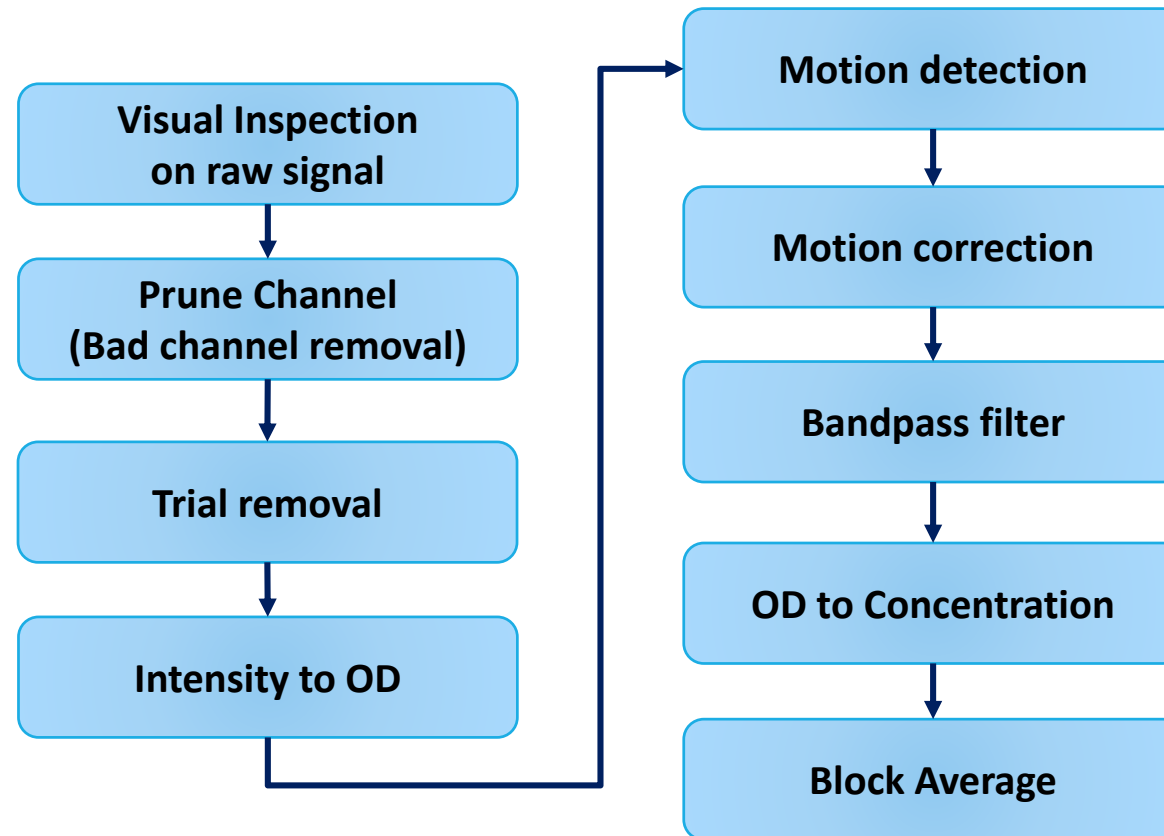
EXIT

	Input Variable	Parameters
hmrR_Intensity2OD		
hmrR_BandpassFilt: Bandpass_Filter_Auxiliary	hpf	0.000
	lpf	0.500
hmrR_BandpassFilt: Bandpass_Filter_OpticalDensity	hpf	0.000
	lpf	0.500
hmrR_OD2Conc	ppf	1.0 1.0 1.0
hmrR_BlockAvg: Block_Average_on_Concentration_Data	trange	-2.0 20.0

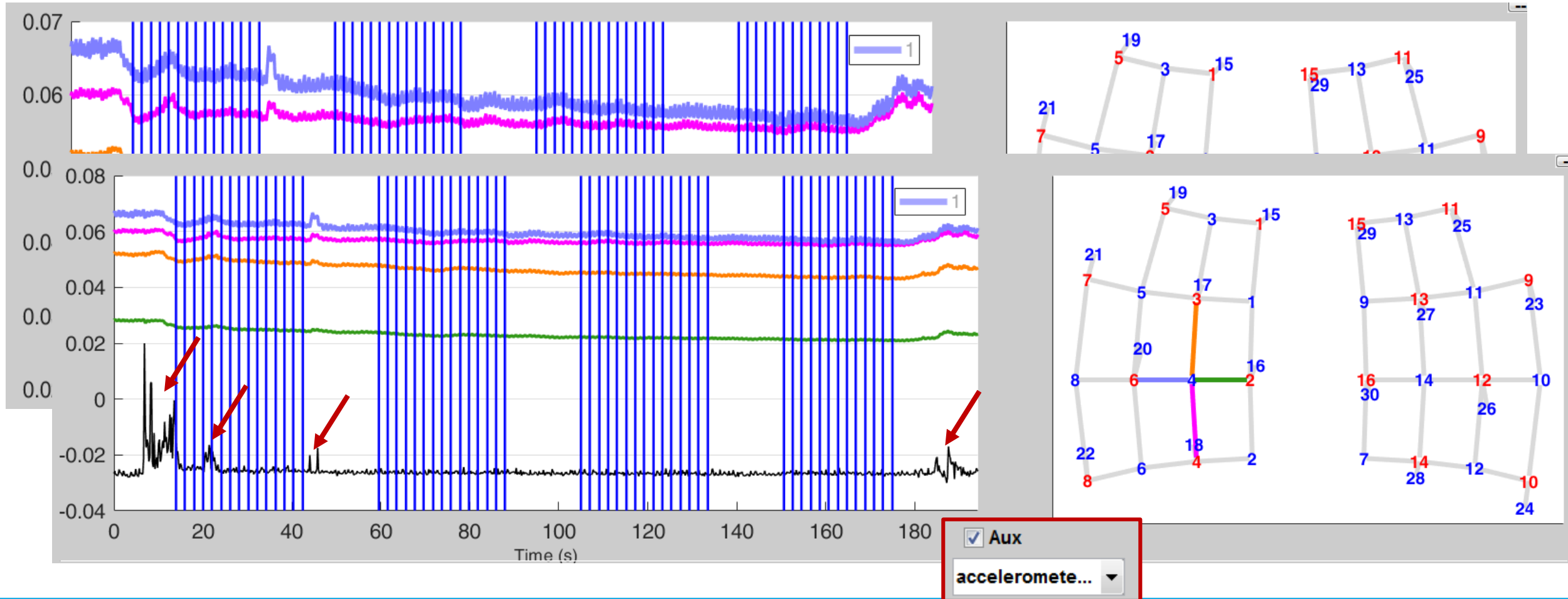
# 訊號處理流程

fNIRS signal processing

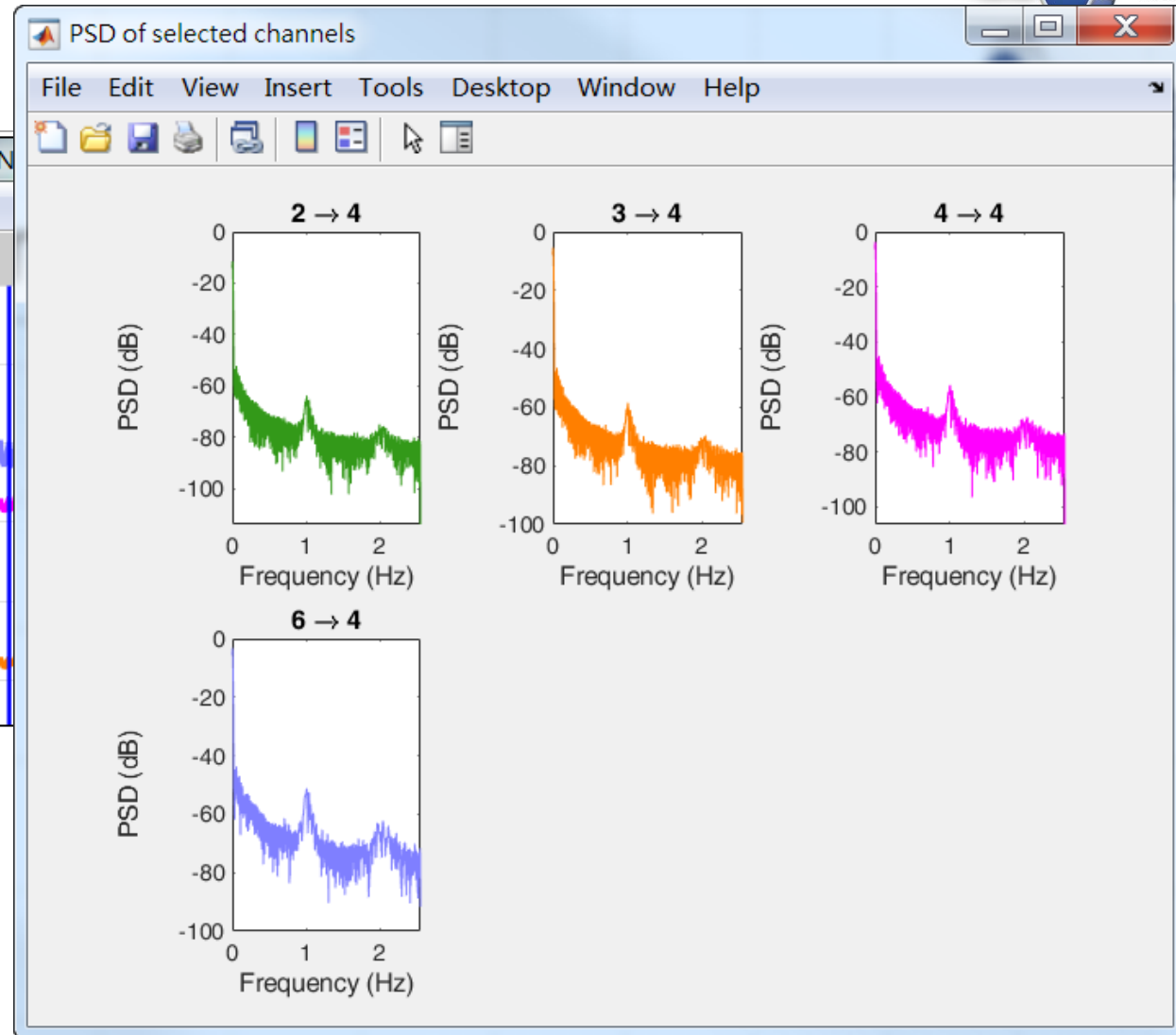
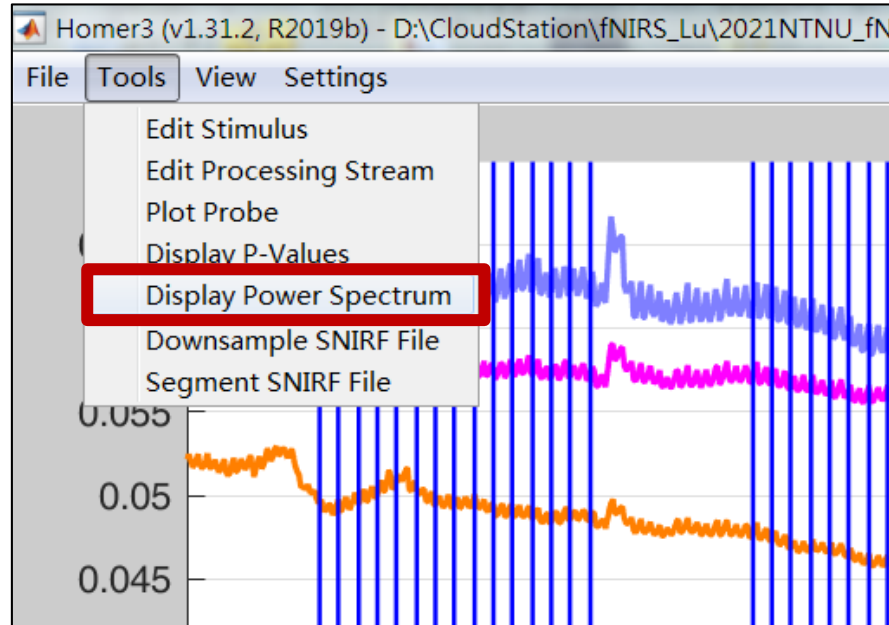
# fNIRS Signal Processing Flow



# Visual Inspection



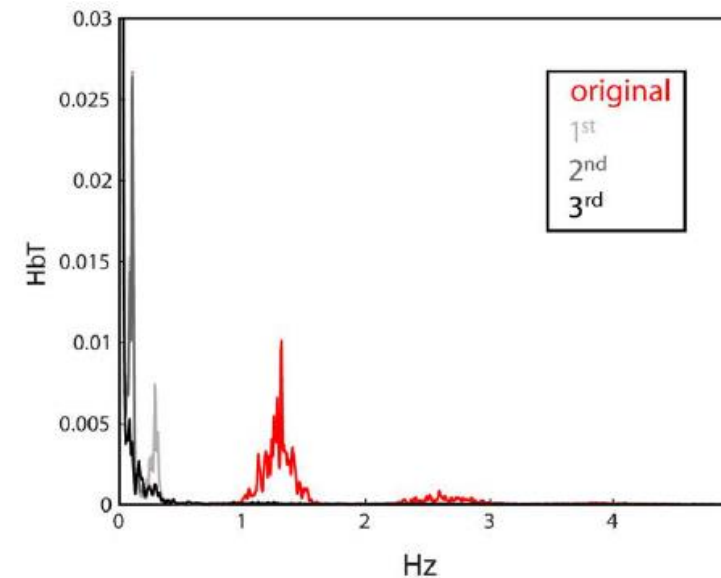
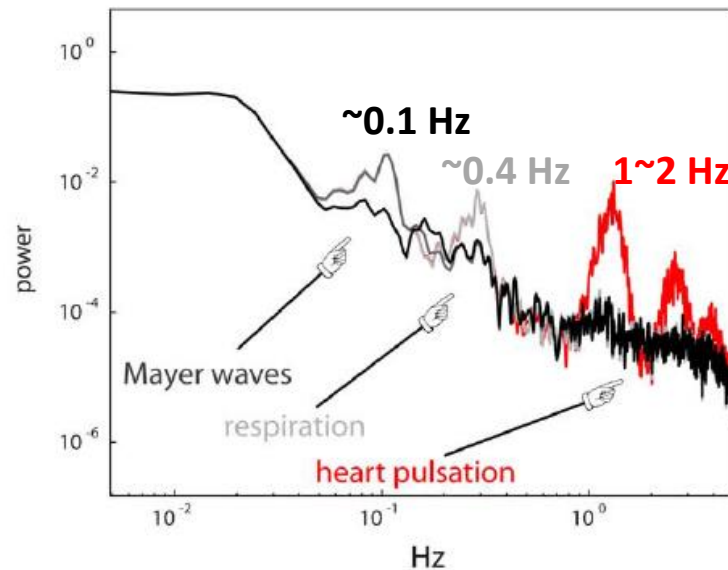
# Visual Inspection





# Physiological components

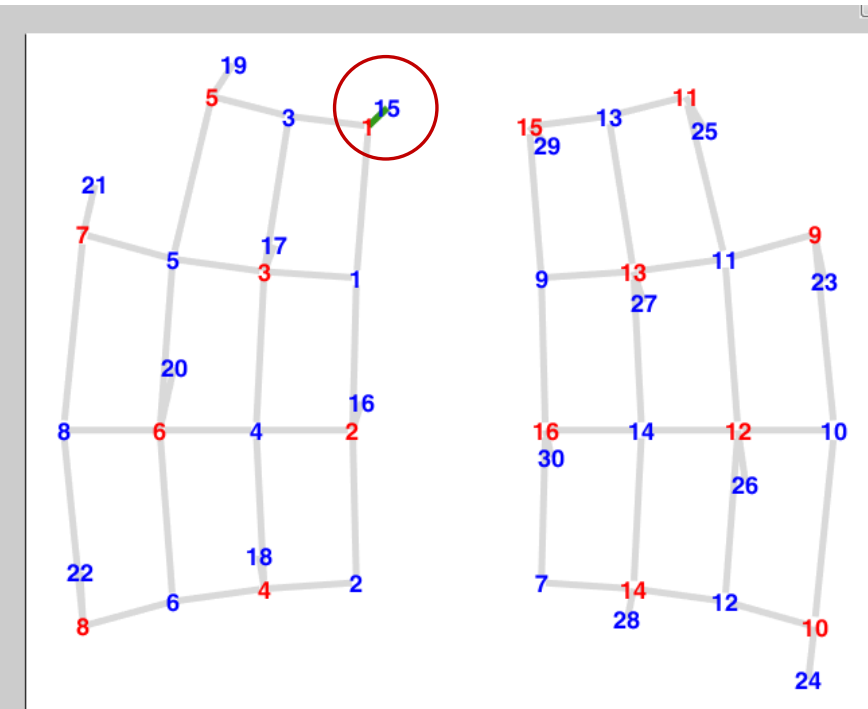
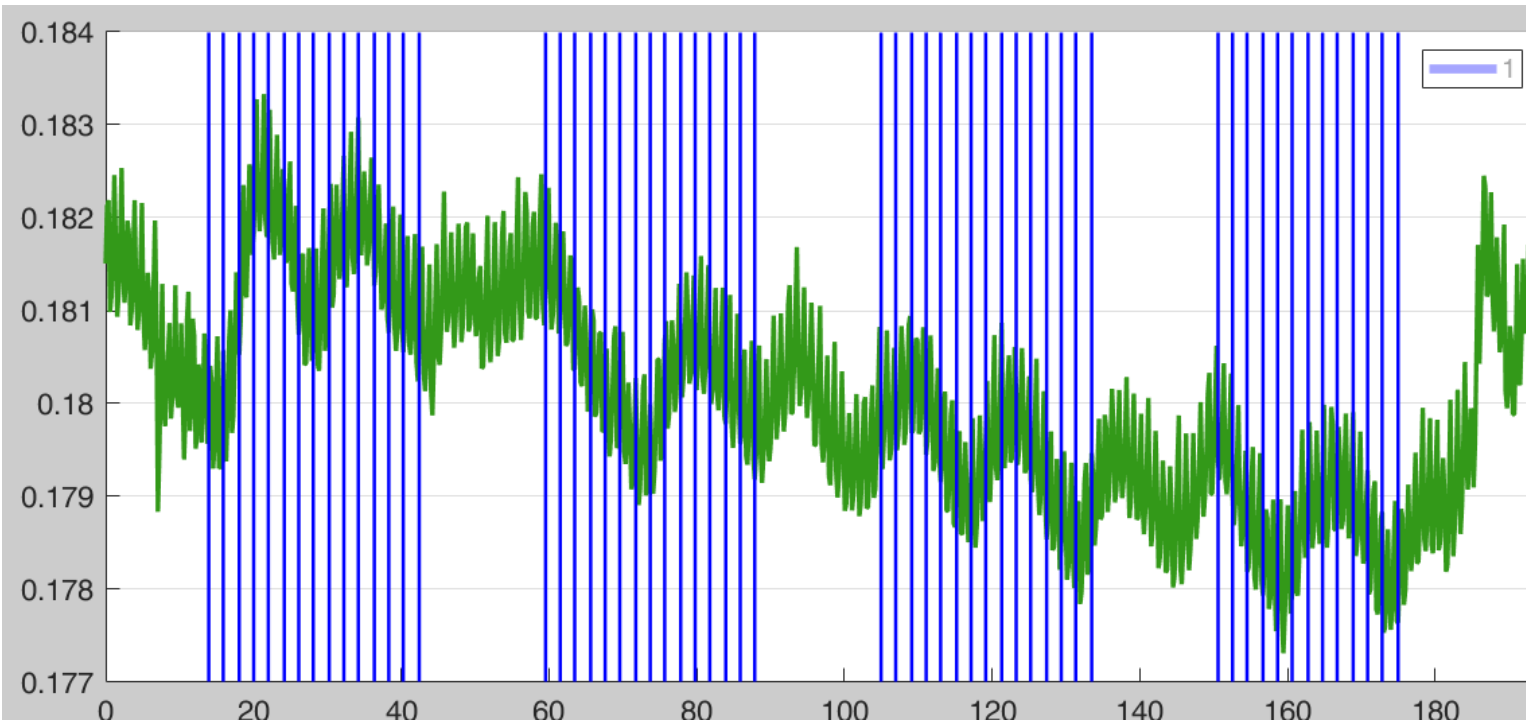
- Heartbeat, respiration, and blood pressure (Mayer waves)



Fekete et al., 2011.

# View Short-Distance Channels

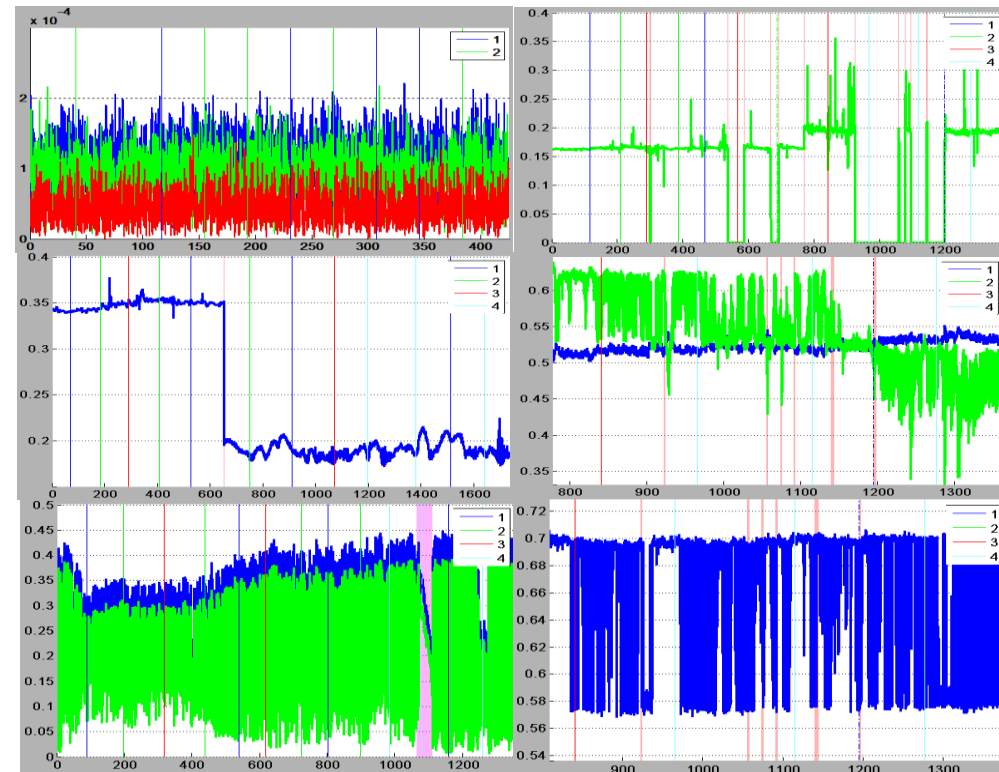
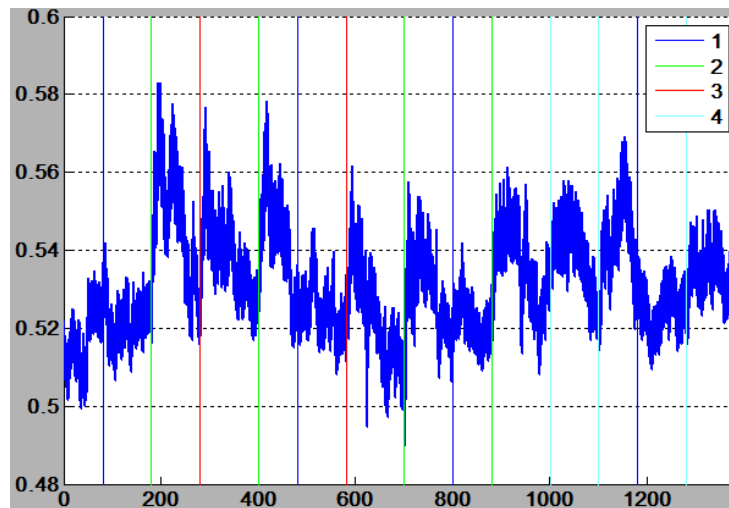
S1-D15



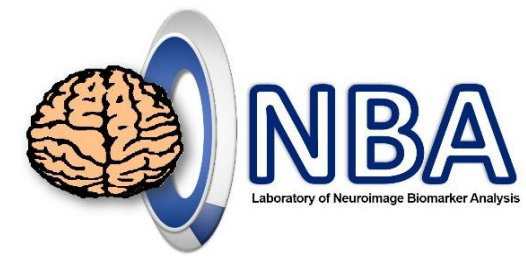
# Visual Inspection

Bad signal quality →

Sufficient signal quality



# Edit (Add/Delete) Stimulate Marks



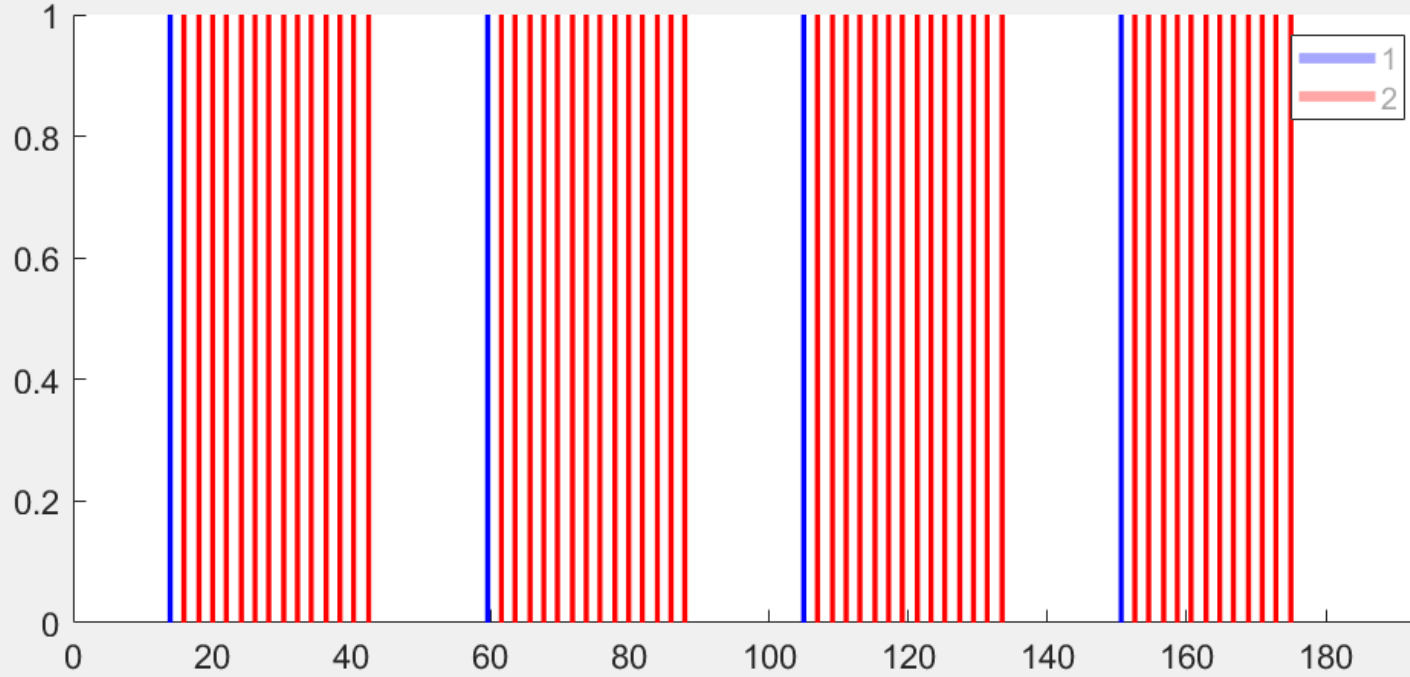
The screenshot displays the Homer3 software interface. The 'Tools' menu is open, with 'Edit Stimulus' highlighted. The main window, 'StimEditGUI: (1.31.2)', shows a plot of stimulus marks (blue vertical lines) over time (0 to 180 seconds). The plot is titled '2021-03-04\_003 :'. Below the plot, there are controls for generating stimulus marks from auxiliary data, including a list of channels (e.g., accelerometer\_1\_x, gyroscope\_1\_x) and options for 'Preview', 'Threshold' (0.0), 'LPF' (0), and 'Rising edge' selection. A 'Generate 0 stim marks' button is present. To the right, a table lists the generated stimulus marks with columns for 'Onset', 'Duration', and 'Amplitude'. Below the table are buttons for 'Rename condition', 'Edit columns', 'Add/Edit', 'Save to file', and 'Exit'.

	Onset	Duration	Amplitude
1	13.9592	10	1
2	15.9252	10	1
3	18.0879	10	1
4	20.0540	10	1
5	22.0201	10	1
6	24.1828	10	1
7	26.1489	10	1
8	28.1149	10	1
9	30.2776	10	1
10	32.2437	10	1
11	34.2098	10	1



File Tools

2021-03-04\_003 :



1

Rename condition

Edit columns

	Onset	Duration	Amplitude
1	13.9592	30	1
2	59.5722	30	1
3	104.9887	30	1
4	150.6017	30	1

Generate stim marks from aux

- accelerometer\_1\_x
- accelerometer\_1\_y
- accelerometer\_1\_z
- gyroscope\_1\_x
- gyroscope\_1\_y
- gyroscope\_1\_z
- accelerometer\_2\_x
- accelerometer\_2\_y
- accelerometer\_2\_z

Preview

Threshold

LPF

Rising edge

Falling edge

Generate 0 stim marks

Edit stim marks manually

Add/Edit

Save to file

Exit

File

Run Subject Group

Registry Functions

- hmrR\_BandpassFilt
- hmrR\_BlockAvg
- hmrR\_GLM
- hmrR\_GLM\_new
- hmrR\_Intensity20D
- hmrR\_MotionArtifact
- hmrR\_MotionArtifactByChannel
- hmrR\_MotionCorrectCbsi
- hmrR\_MotionCorrectPCA
- hmrR\_MotionCorrectPCArecuse
- hmrR\_MotionCorrectRLOESS
- hmrR\_MotionCorrectSpline
- hmrR\_MotionCorrectSplineSG
- hmrR\_MotionCorrectWavelet
- hmrR\_OD2Conc
- hmrR\_PCFilter
- hmrR\_PreprocessIntensity\_MedianFilter
- hmrR\_PreprocessIntensity\_NAN
- hmrR\_PreprocessIntensity\_Negative
- hmrR\_PreprocessOD\_LinearFit
- hmrR\_PruneChannels
- hmrR\_StimCriteria

Usage Options

- Cbsi\_Motion\_Correction

Add

Delete

Up

Down

Load

Save

Exit

Current Processing Stream

- hmrR\_PruneChannels : Prune\_Channels
- hmrR\_Intensity20D : Intensity\_to\_Delta\_OD
- hmrR\_MotionArtifactByChannel : Motion\_Artifacts\_By\_Channel
- hmrR\_MotionCorrectWavelet : Wavelet\_Motion\_Correction
- hmrR\_BandpassFilt : Bandpass\_Filter\_OpticalDensity
- hmrR\_OD2Conc : Delta\_OD\_to\_Conc
- hmrR\_MotionCorrectCbsi : Cbsi\_Motion\_Correction
- hmrR\_BlockAvg : Block\_Average\_on\_Concentration\_Data

Clear All

```
mlActAuto = hmrR_PruneChannels(data, probe, mlActMan, tIncMan, dRange, SNRthresh, SDrange)

dRange: [1e4, 1e7]
SNRthresh: 2
SDrange: [0.0, 45.0]
```

# Motion Correction Techniques

---

## Spline interpolation

Scholkmann et al., 2010

- hmrMotionCorrectSpline.m

## Principal component analysis (PCA)

Zhang et al., 2005

- hmrMotionCorrectPCA.m

## Wavelet filtering

Molavi and Dumont, 2012

- hmrMotionCorrectWavelet.m

## Correlation-based signal improvement (CBSI)

Cui et al., 2010

- hmrMotionCorrectCbsi



# Edit Options

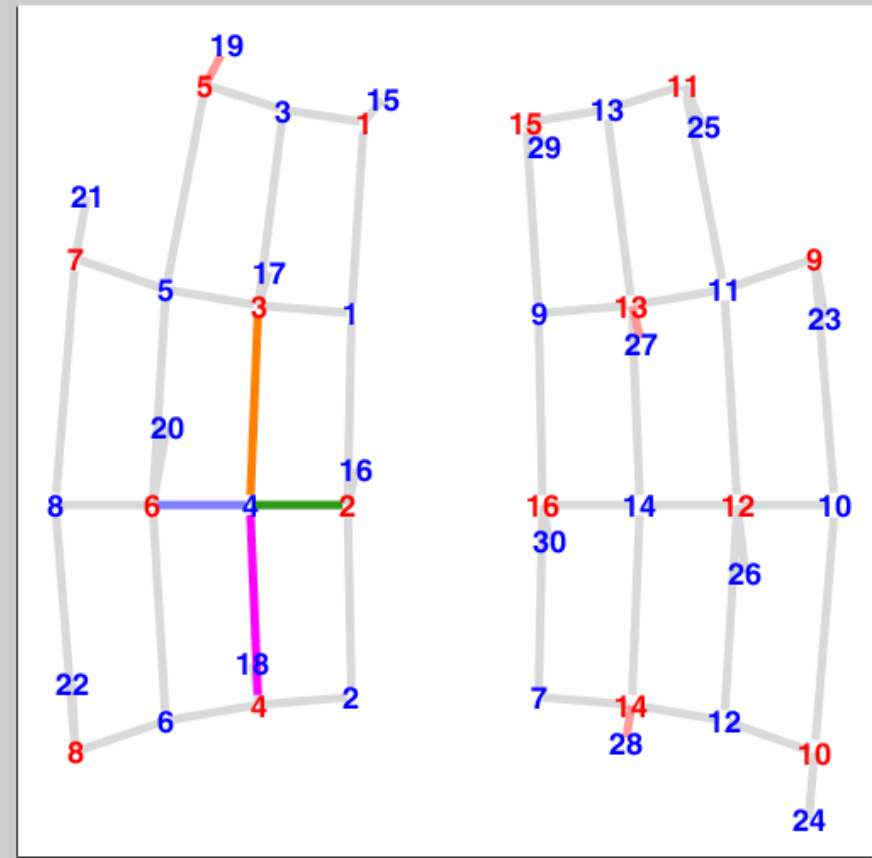
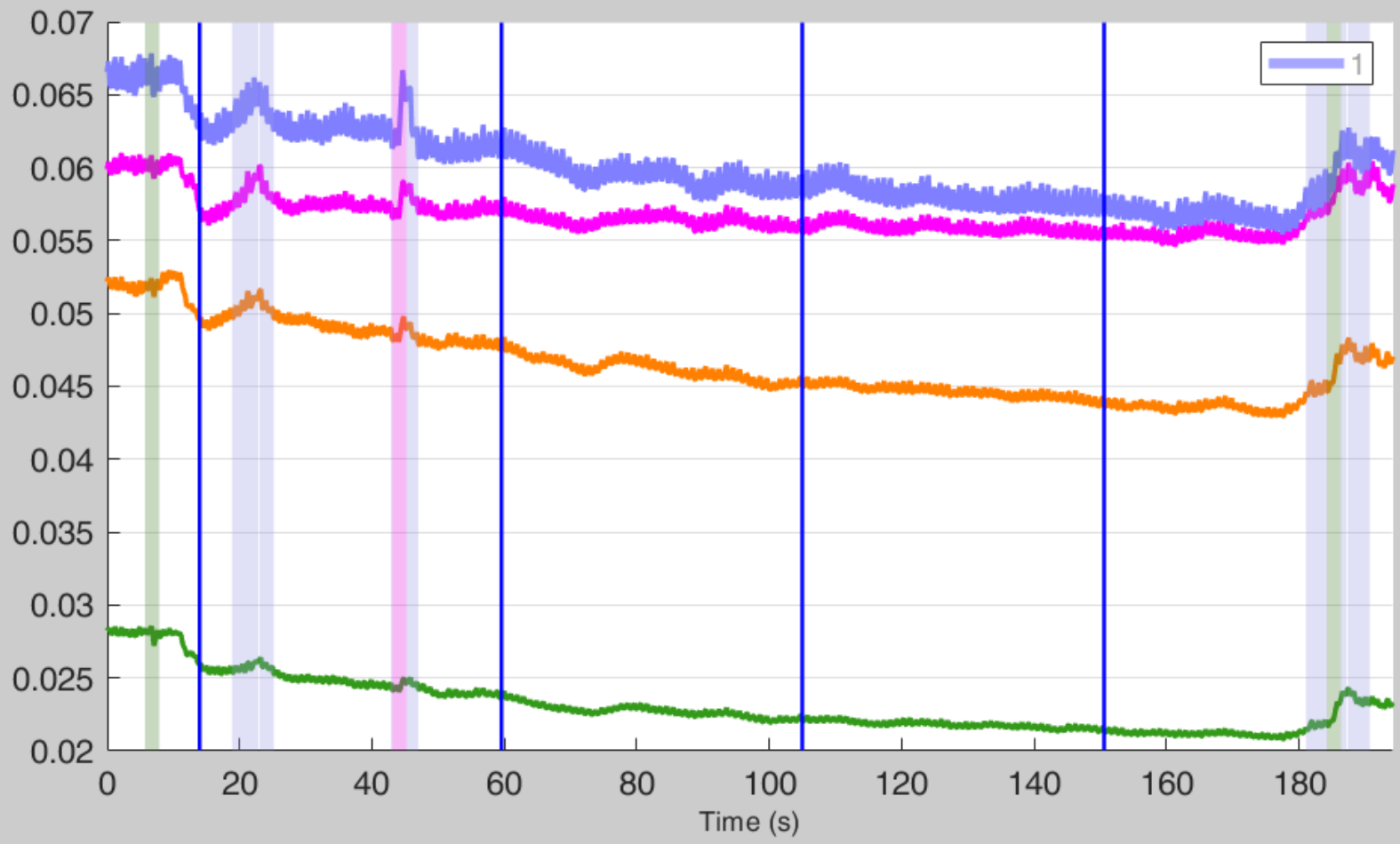
**RUN**

**Edit Options**  Apply to all

ProcStreamOptionsGUI: (1.31.2) - D:\CloudStation\fNIRS\_Lu\2021NTNU\_fNIRSswor... [min] [max] [close]

**EXIT**

hmrR_PruneChannels	dRange	1e-02 1e+00
	SNRthresh	2
	SDrange	0.0 45.0
hmrR_Intensity2OD		
hmrR_MotionArtifactByChannel	tMotion	0.5
	tMask	1.0
	STDEVthresh	5.0
	AMPthresh	0.05
hmrR_MotionCorrectWavelet	iqr	1.50
	turnon	1
hmrR_BandpassFilt: Bandpass_Filter_OpticalDensity	hpf	0.010
	lpf	0.030
hmrR_OD2Conc	ppf	1.0 1.0 1.0
hmrR_MotionCorrectCbsi	turnon	1
hmrR_BlockAvg: Block_Average_on_Concentration_Data	trange	-5.0 35.0



Current Processing Element

2021-03-04\_003.snirf

Processing Level

Group

**RUN**

Edit Options  Apply to all

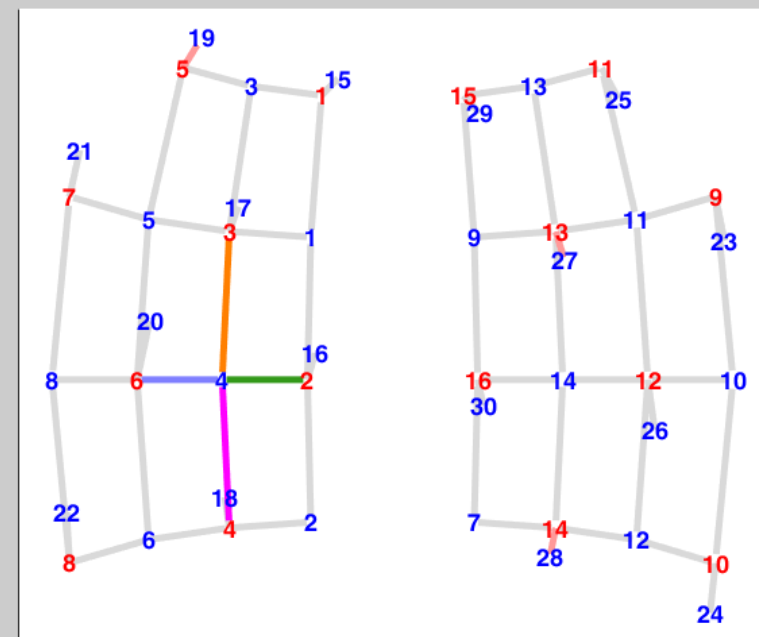
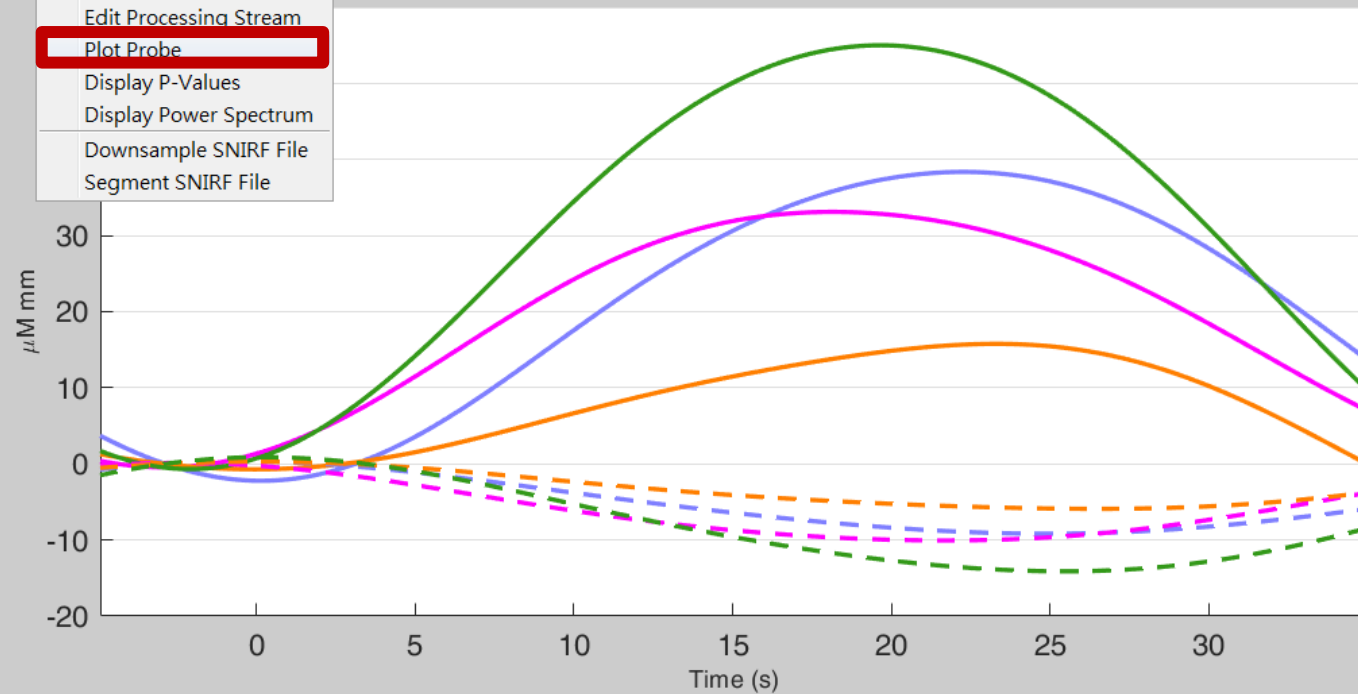
Exclude data

Show Excluded Manual  Edit Excluded Time

Show Excluded Auto  Edit Excluded Stims

Show Excluded by Channel **Include all**

- File
  - Tools
  - View
  - Settings
- Edit Stimulus
  - Edit Processing Stream
  - Plot Probe**
  - Display P-Values
  - Display Power Spectrum
  - Downsample SNIRF File
  - Segment SNIRF File



Current Processing Element

- 2021-03-04\_003.snirf

1 files loaded successfully  
0 files failed to load

Processing Level

- Group
- Subj
- Run

**RUN**

Edit Options  Apply to all

Plot Type Select

- Raw Data
  - OD
  - Conc
- HbO  
HbR  
HbT
- HRF
- 1
- Aux

accelerometer...

Exclude data

- Show Excluded Manual
  - Show Excluded Auto
  - Show Excluded by Channel
  - Edit Excluded Time
  - Edit Excluded Stims
- Include all

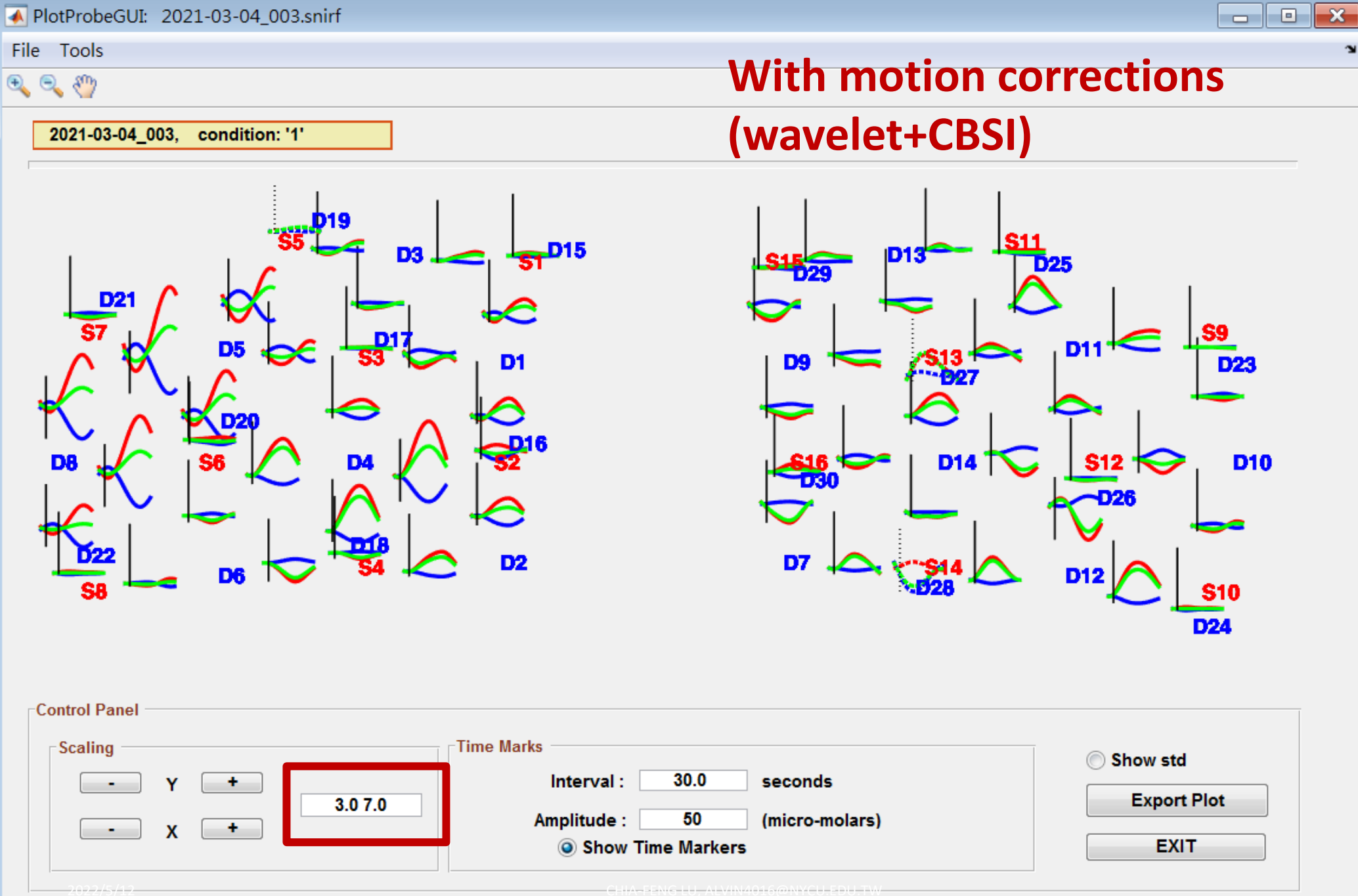
Data Plot Window

- Pan Left/Right
- < > Reset View
- Fix X-range
- 0 400
- Fix Y-range
- 2 2

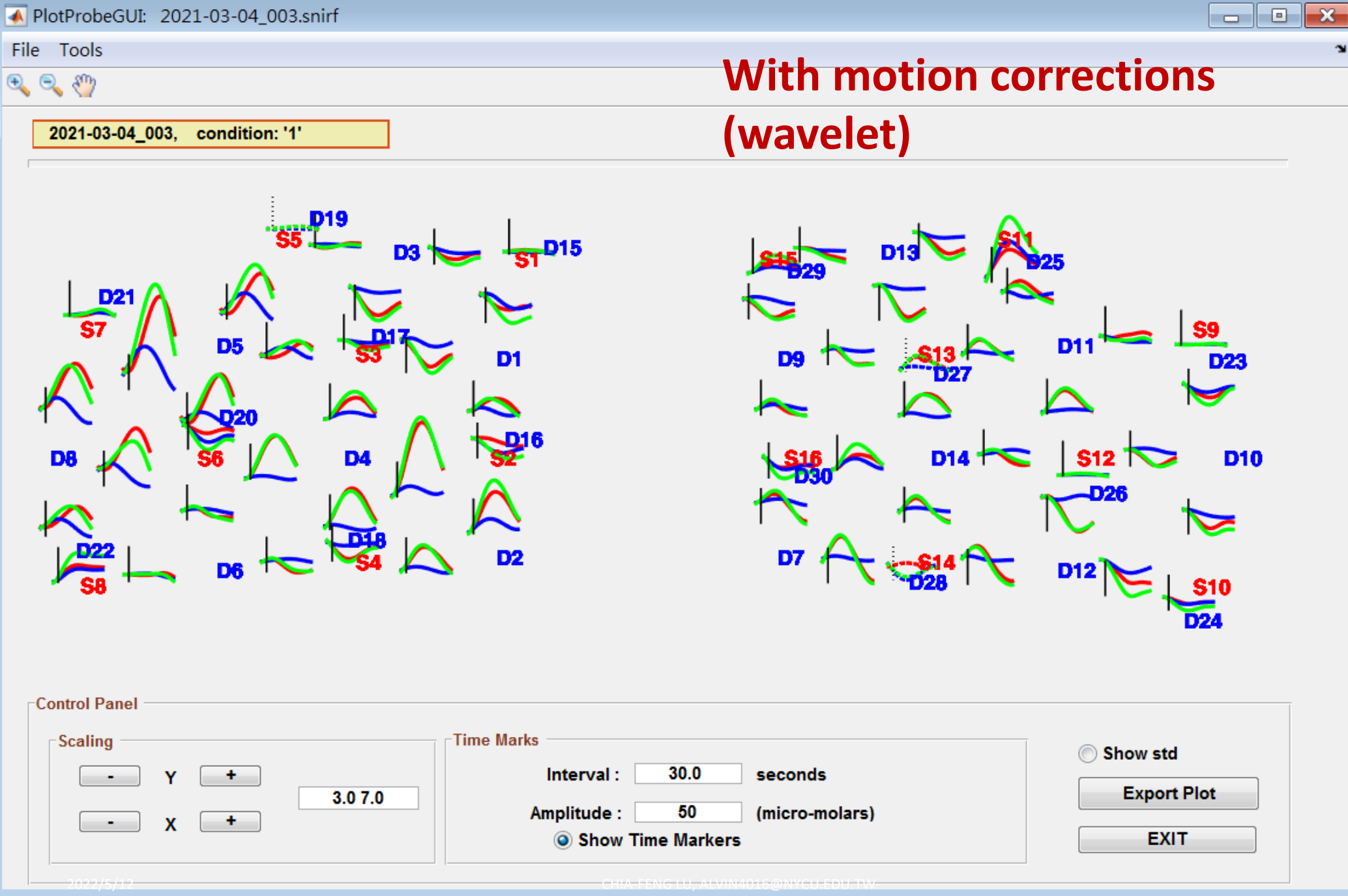
Probe Plot Window

- Pan Display
- < Λ >
- V
- Zoom In Zoom Out
- Reset View

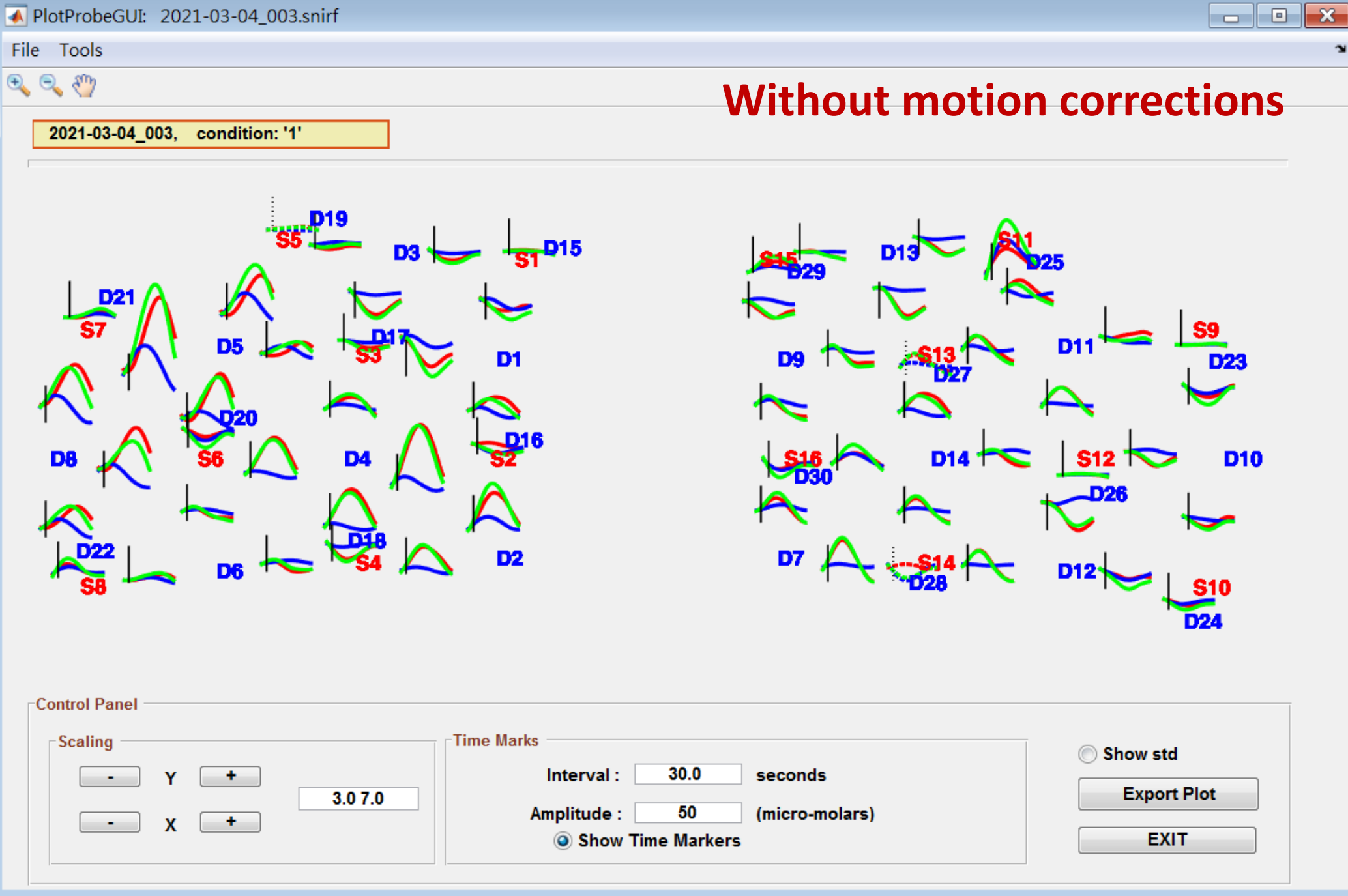
# With motion corrections (wavelet+CBSI)



# With motion corrections (wavelet)



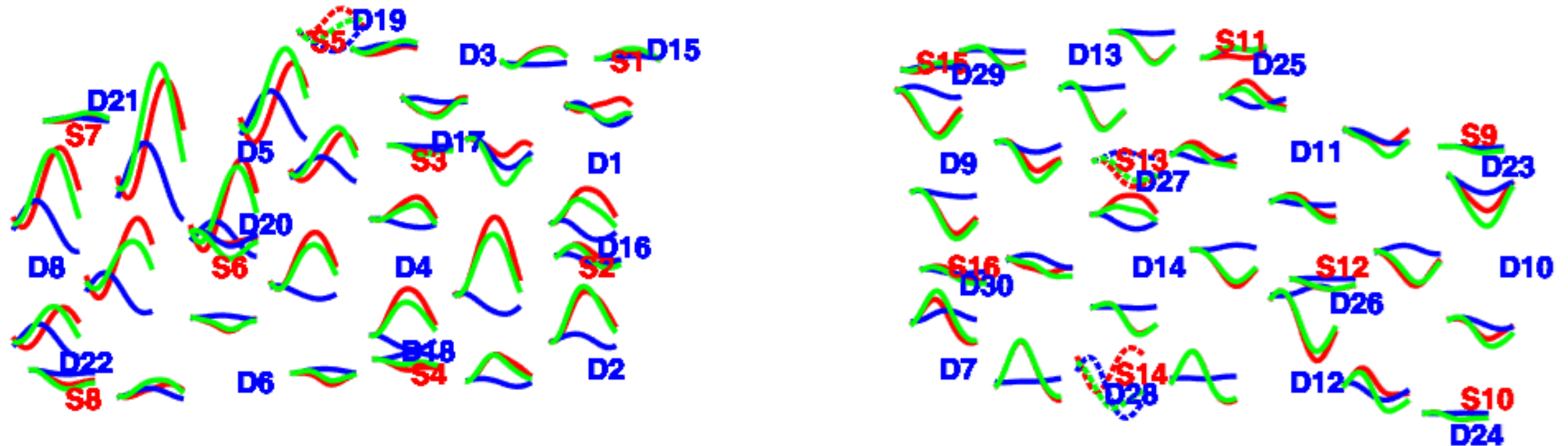
# Without motion corrections



ProcStreamOptionsGUI: (1.31.2) - D:\CloudStation\fnIRS\_Lu\2021NTNU\_fnIRSworkshop\2021-03-04\2021-0...

hmrR_PruneChannels	dRange	1e-02 1e+00
	SNRthresh	2
	SDrange	0.0 45.0
hmrR_Intensity2OD		
hmrR_MotionCorrectPCArecurse	tMotion	0.5
	tMask	1.0
	STDEVthresh	5.0
	AMPthresh	0.05
	nSV	0.97
	maxIter	5
	turnon	1
hmrR_MotionArtifactByChannel	tMotion	0.5
	tMask	1.0
	STDEVthresh	5.0
	AMPthresh	0.05
hmrR_MotionCorrectWavelet	iqr	1.50
	turnon	0
hmrR_BandpassFilt: Bandpass_Filter_OpticalDensity	hpf	0.010
	lpf	0.030
hmrR_OD2Conc	ppf	1.0 1.0 1.0
hmrR_MotionCorrectCbsi	turnon	0
hmrR_BlockAvg: Block_Average_on_Concentration_Data	trange	-5.0 35.0

# Motion correction by targeted recursive PCA





# 定量分析

fNIRS Quantitative Analysis

# Processed Data from HOMER2/HOMER3

## Homer2 (\*.nirs)

- MATLAB mat-file format (\*.nirs)
  - `load('Subj01.nirs','-mat')`
- **procInput:**
  - Employed functions and parameters
- **procResult:**
  - Processed signals and parameters
- **tIncMan:**
  - Manually excluded time interval

Workspace	
Name ^	Value
SD	
aux	
d	
ml	
procInput	
procResult	
s	
t	
tIncMan	
userdata	

Variables - output	
Property ^	Value
dod	1x1 DataClass
dc	1x1 DataClass
dodAvg	[]
dcAvg	1x1 DataClass
dodAvgStd	[]
dcAvgStd	1x1 DataClass
dodSum2	[]
dcSum2	1x1 DataClass
tHRF	[]
nTrials	1x1 cell
ch	[]
grpAvgPass	[]
misc	1x1 struct

## Homer3 (\*.mat)

- MATLAB mat-file format
  - `load('2021-03-04_003.mat')`

Workspace	
Name ^	Value
output	1x1 ProcResultClass

# Output (1/2)

The Homer 3 has to be included in the search path .

## dod: optical density signals

- data length x (channels x 2 wavelengths)

## dc: Hb concentration signals

- data length x (channels x 3 HbO/R/T)

## dcAvg: block averages of Hb signals

- Block length x (channels x 3 HbO/R/T  
x conditions)

## dcAvgStd: STD of block averages

- Block length x (channels x 3 HbO/R/T  
x conditions)

Property ^	Value
dod	1x1 DataClass
dc	1x1 DataClass
dodAvg	[]
dcAvg	1x1 DataClass
dodAvgStd	[]
dcAvgStd	1x1 DataClass
dodSum2	[]
dcSum2	1x1 DataClass
tHRF	[]
nTrials	1x1 cell
ch	[]
grpAvgPass	[]
misc	1x1 struct

Property ^	Value
dataTimeSeries	989x180 double
time	989x1 double
measurementList	1x180 MeasListClass

Property ^	Value
dataTimeSeries	204x360 double
time	1x204 double
measurementList	1x360 MeasListClass

# Output (2/2)

**time:** time axis (in second) of block

- 1 x Block length

**nTrials:** number of each condition

- (cell array) 1 x conditions

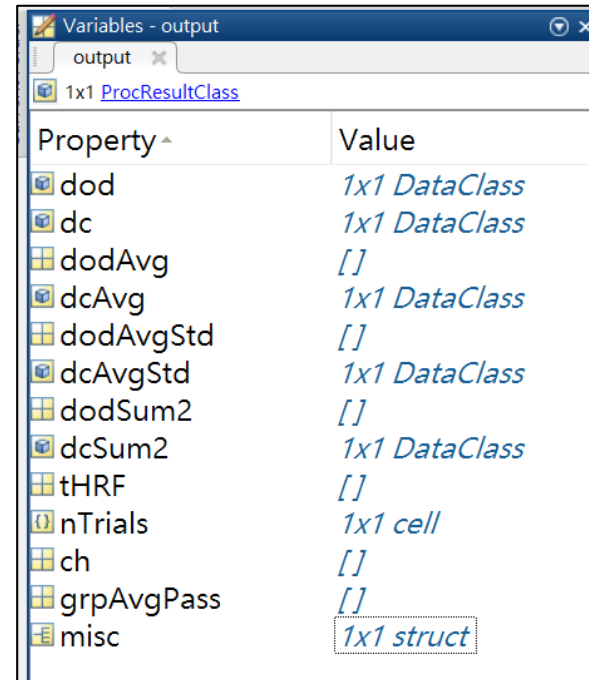
**tIncAuto:** included time interval

- (cell array) Data length x 1

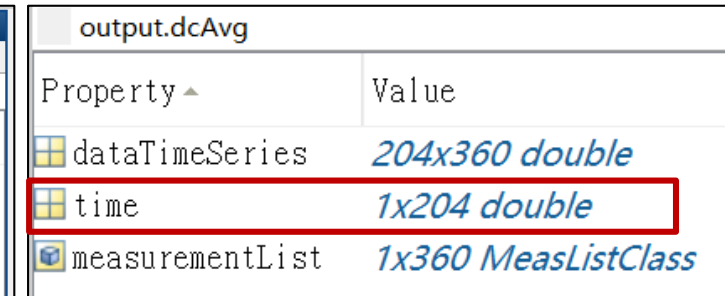
**tIncAutoCh:** included time interval

for each channel

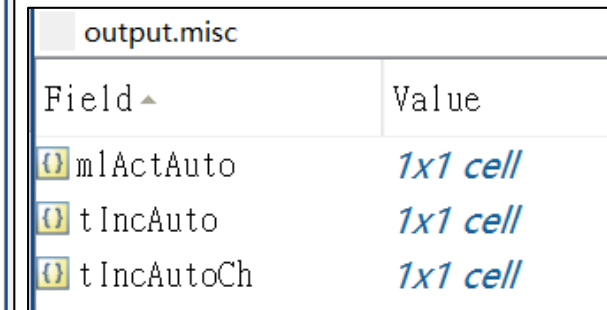
- (cell array) Data length x  
(channel x 2 wavelengths)



Property ^	Value
dod	1x1 DataClass
dc	1x1 DataClass
dodAvg	[]
dcAvg	1x1 DataClass
dodAvgStd	[]
dcAvgStd	1x1 DataClass
dodSum2	[]
dcSum2	1x1 DataClass
tHRF	[]
nTrials	1x1 cell
ch	[]
grpAvgPass	[]
misc	1x1 struct

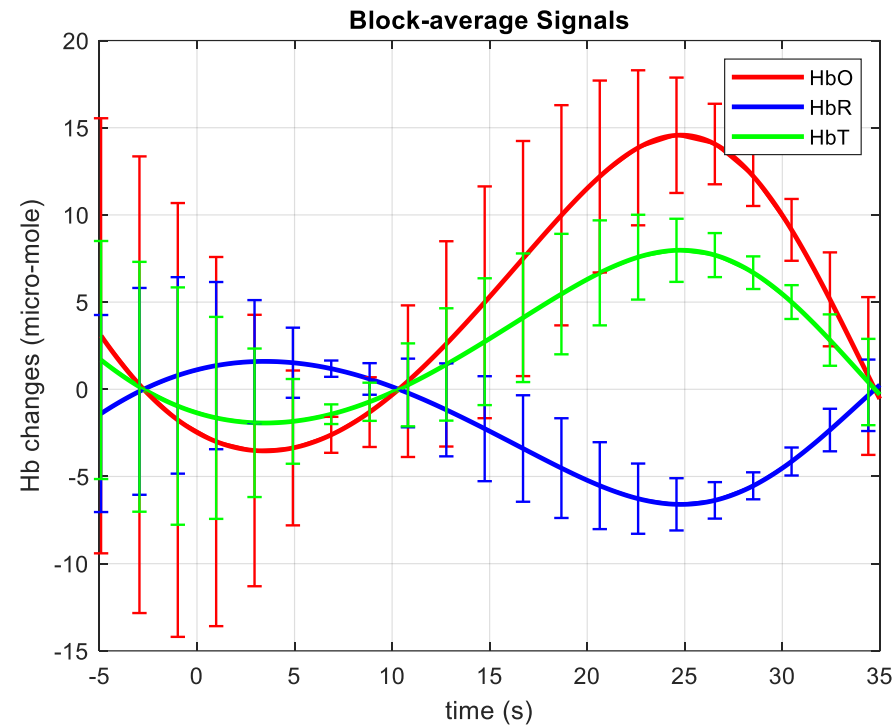
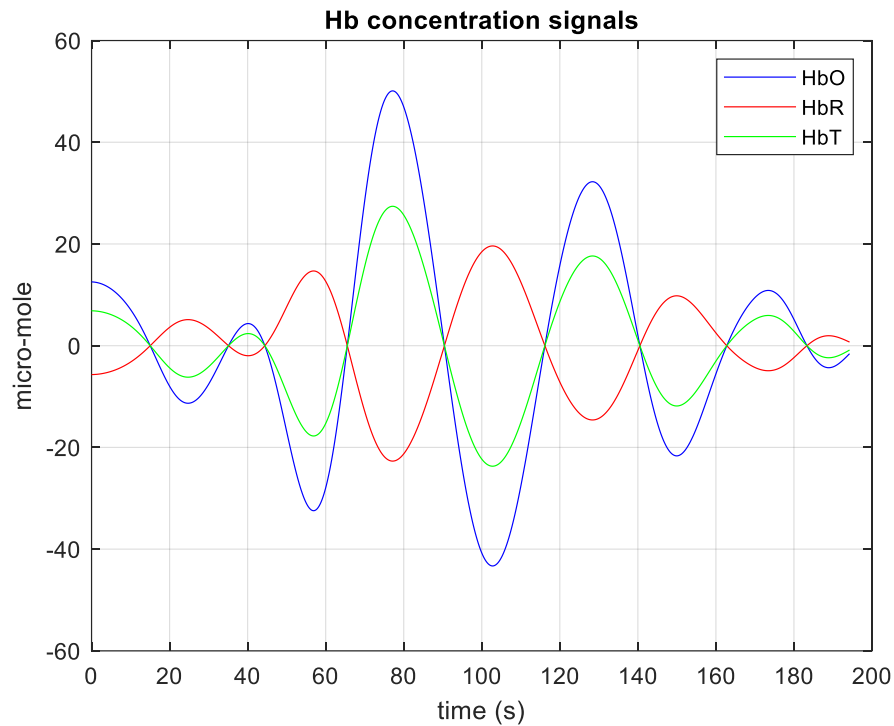


Property ^	Value
dataTimeSeries	204x360 double
time	1x204 double
measurementList	1x360 MeasListClass



Field ^	Value
mlActAuto	1x1 cell
tIncAuto	1x1 cell
tIncAutoCh	1x1 cell

# NIRS\_SigPlotAna\_CF.m



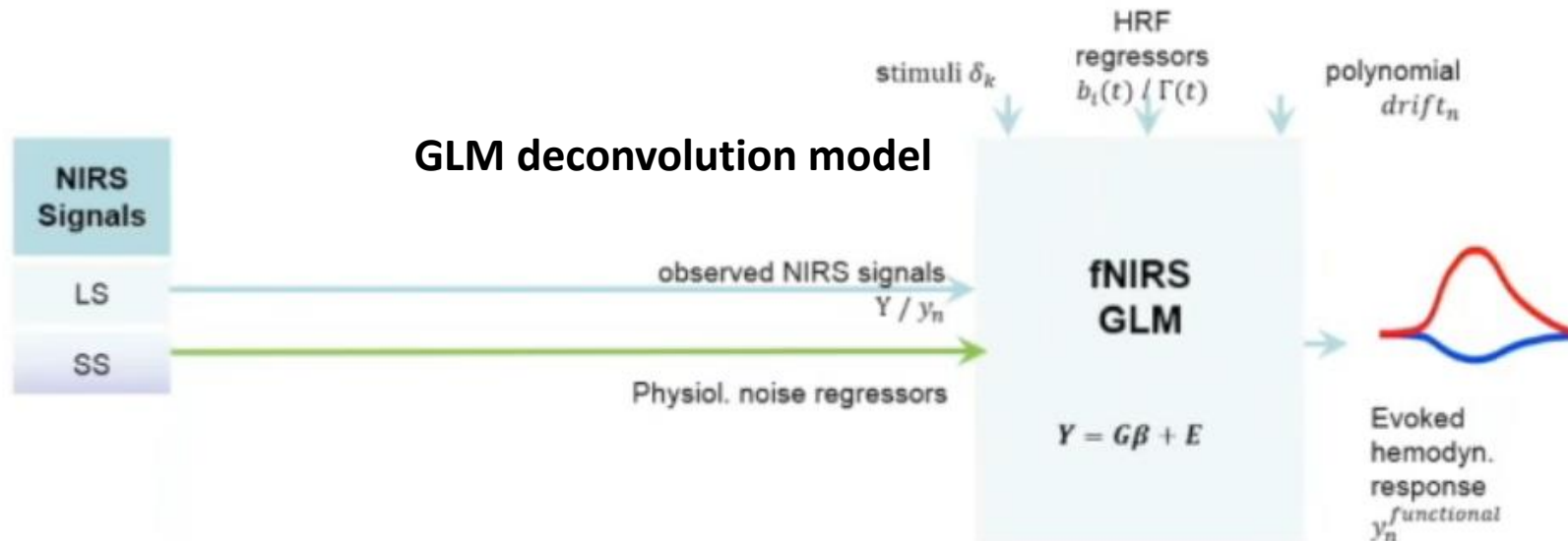
Workspace	
Name ▲	Value
HbOmean	7.0490
HbOpeak	14.5751
HbRmean	-3.1924
HbRpeak	-6.6009
HbTmean	3.8566
HbTpeak	7.9742

# GLM with SS regression

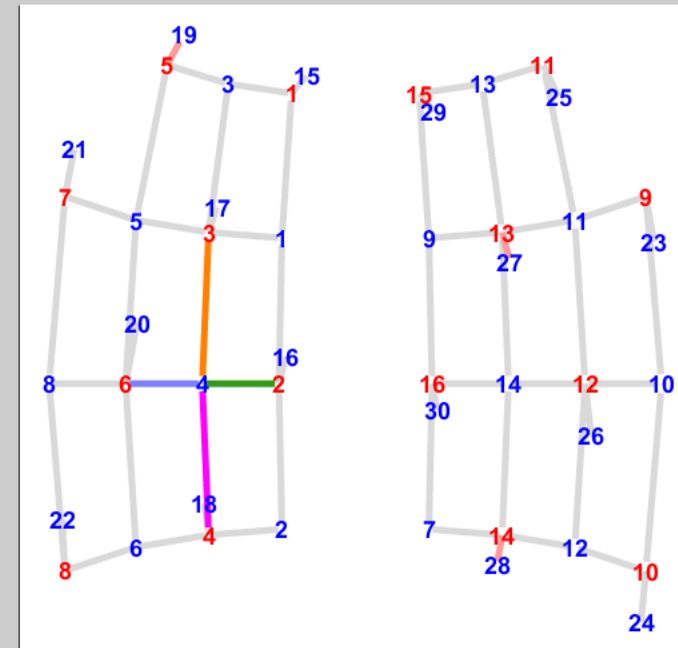
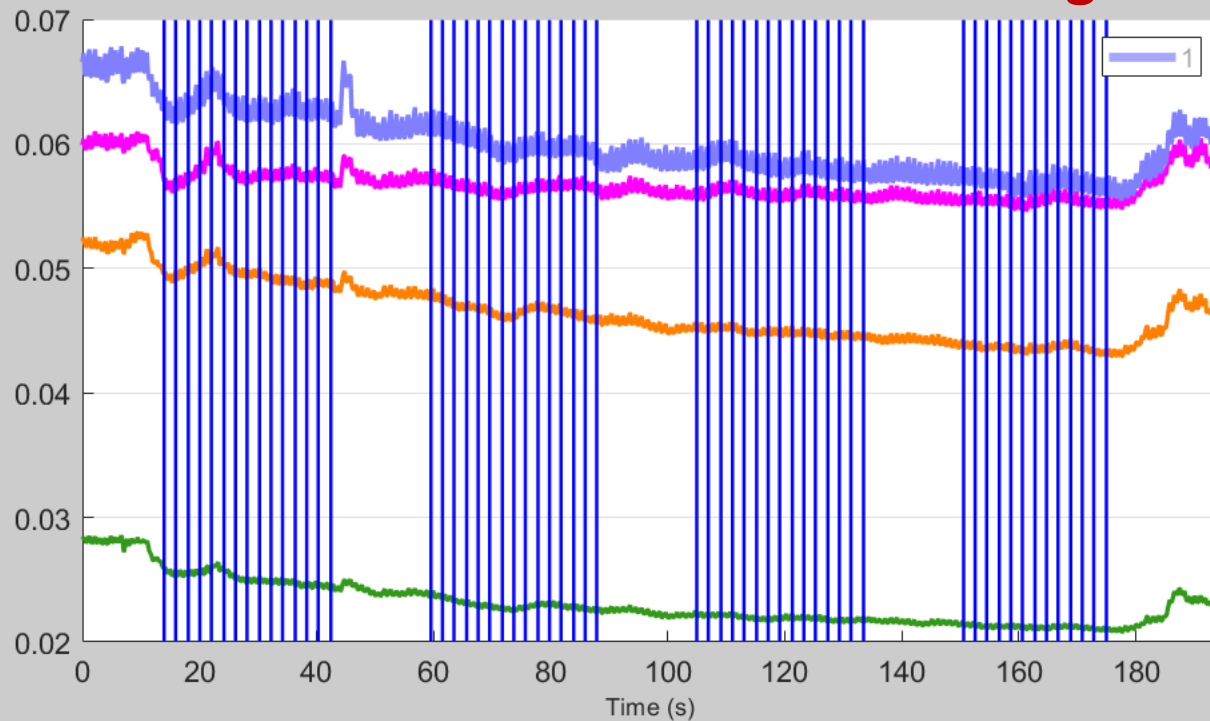
Improve signal quality

# Eliminate confounding noise

**Systemic physiology** and **motion-induced artifacts** represent two major sources of confounding noise in functional near infrared spectroscopy (fNIRS) that can inflate false positive rates (i.e., type I errors) of detecting evoked hemodynamic responses.



# An event-related design would be better.



Current Processing Element

- 2021-03-04\_003.snirf

1 files loaded successfully  
0 files failed to load

Processing Level

- Group
- Subj
- Run

**RUN**

Edit Options  Apply to all

Exclude data

- Show Excluded Manual  Edit Excluded Time
- Show Excluded Auto  Edit Excluded Stims
- Show Excluded by Channel

Plot Type Select

- Raw Data  HRF
- OD  -- 1
- Conc  Aux
- acceleromet...

Data Plot Window

- Pan Left/Right
- Fix X-range 0 400
- Fix Y-range -2 2

Probe Plot Window

- Pan Display
-



rkshop\2021-03-04\2021-03-04\ChouTest

**Current Processing Stream**

hmrR_PruneChannels	: Prune_Channels
hmrR_Intensity2OD	: Intensity_to_Delta_OD
hmrR_BandpassFilt	: Bandpass_Filter_OpticalDensity
hmrR_OD2Conc	: Delta_OD_to_Conc
hmrR_MotionCorrectCbsi	: Cbsi_Motion_Correction
hmrR_GLM_new	: GLM_HRF_Drift_SS_Concentration

hmrR\_GLM(data, stim, probe, mlActAuto, Aaux, tIncAuto, trange, rcMap, glmSolveMethod, idxBasis, paramsBasis, rhoSD\_ssThresh, flagNuisanceRMethod, driftOrder)

**Apply general linear model (GLM) to estimate hemodynamic response function (HRF)**

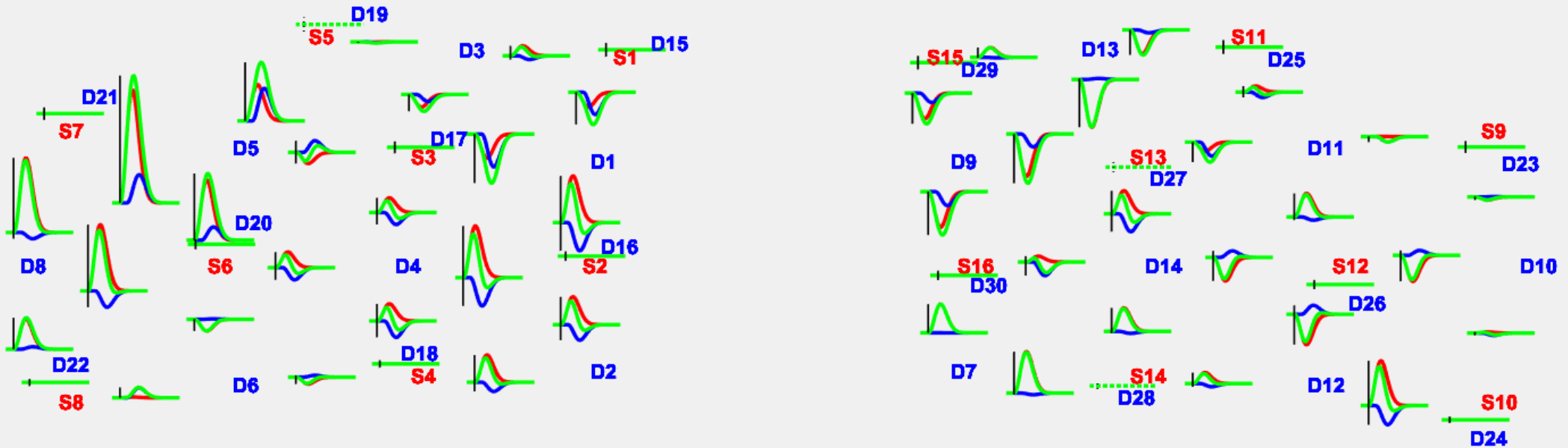
ProcStreamOptionsGUI: (1.31.2) - D:\CloudStation\fnIRS\_Lu\2021NTNU\_fnIRS...

<b>hmrR_PruneChannels</b>	<b>dRange</b>	<b>1e-02 1e+00</b>
	<b>SNRthresh</b>	<b>2</b>
	<b>SDrange</b>	<b>0.0 45.0</b>
<b>hmrR_Intensity2OD</b>		
<b>hmrR_BandpassFilt: Bandpass_Filter_OpticalDensity</b>	<b>hpf</b>	<b>0.010</b>
	<b>lpf</b>	<b>0.030</b>
<b>hmrR_OD2Conc</b>	<b>ppf</b>	<b>1.0 1.0 1.0</b>
<b>hmrR_MotionCorrectCbsi</b>	<b>turnon</b>	<b>0</b>
<b>hmrR_GLM_new</b>	<b>trange</b>	<b>-2.0 15.0</b>
	<b>glmSolveMethod</b>	<b>1</b>
	<b>idxBasis</b>	<b>2</b>
	<b>paramsBasis</b>	<b>0.1 3.0 1.8 3.0</b>
	<b>rhoSD_ssThresh</b>	<b>15.0</b>
	<b>flagNuisanceRMethod</b>	<b>1</b>
	<b>driftOrder</b>	<b>3</b>



# HRF estimated by GLM with regression of short separation channels

2021-03-04\_003, condition: '1'



### Control Panel

#### Scaling

Y   
 X

3.0 8.0

#### Time Marks

Interval :  seconds  
 Amplitude :  (micro-molars)  
 Show Time Markers

Show std

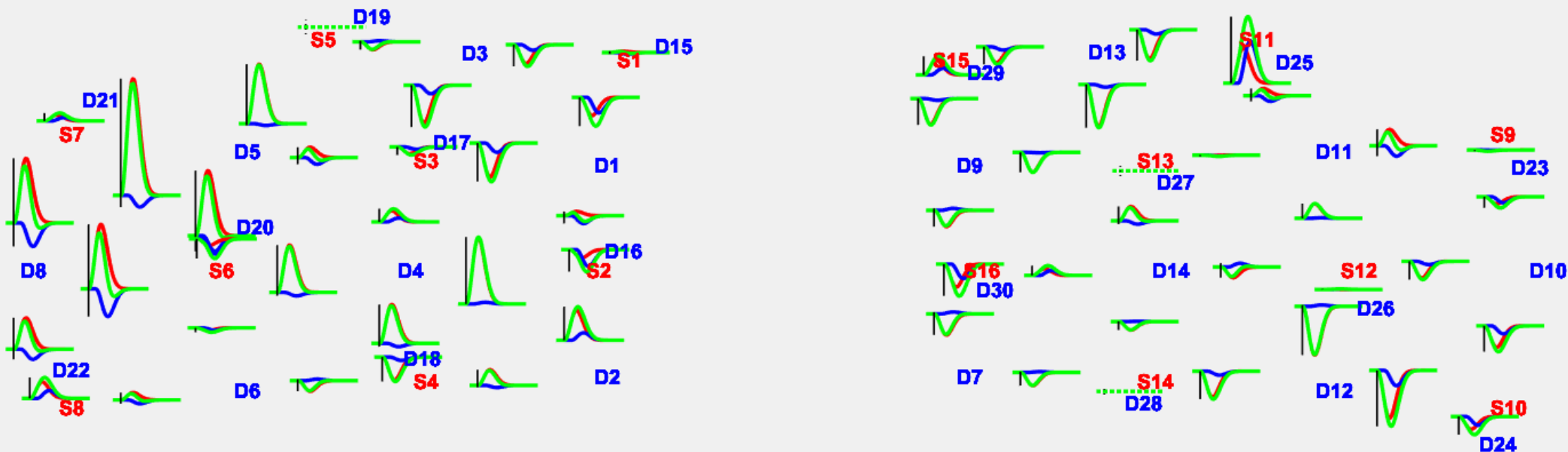
Export Plot

EXIT



# HRF estimated by GLM without regression of short separation channels

2021-03-04\_003, condition: '1'



### Control Panel

#### Scaling

Y   
 X

3.0 8.0

#### Time Marks

Interval :  seconds

Amplitude :  (micro-molars)

Show Time Markers

Show std



盧家鋒 Chia-Feng Lu, PhD

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**Q & A**

Thanks for your attention :)