

# User manual for Delphos Viewer in AnyWave

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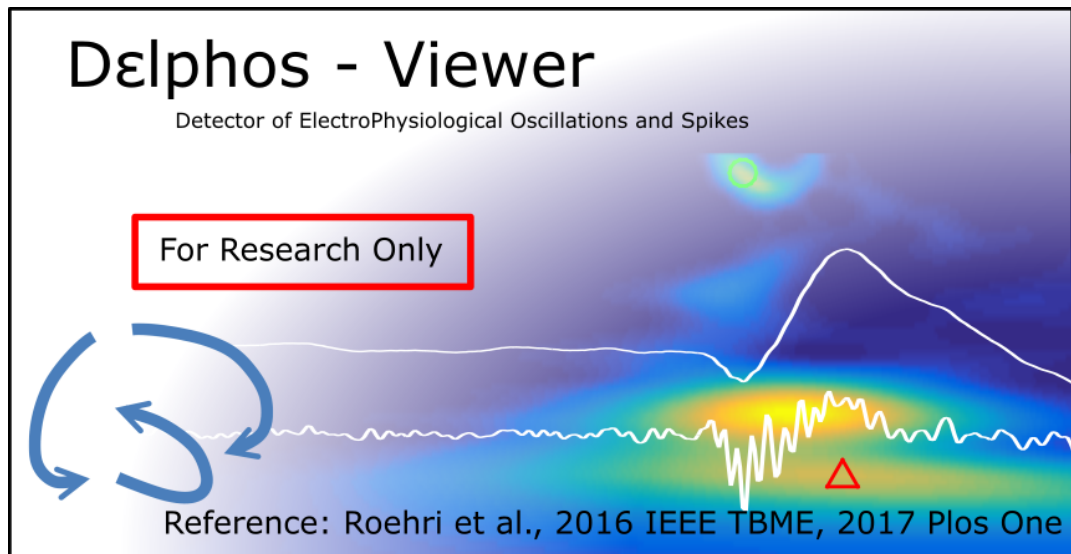


Figure 1: Delphos Viewer splash screen



## 1 Preamble

Delphos, standing for **D**etector of **E**lectro**P**hysiological **O**scillations and **S**pikes, is a detector based on the ZH0-normalisation of the wavelet transform described in [Roehri et al., 2016]. As its name suggests, Delphos was designed to detect both oscillations and spikes. Moreover, because the detection happens in the time-frequency plane, the oscillations are not restrained to a frequency band. Two separate interfaces were developed: *Delphos* and *Delphos Viewer*, the multi-channel detection algorithm and the single channel reviewer, respectively. This manual is for the Delphos Viewer.

Delphos Viewer was designed to display the raw signal of a single channel along its ZH0 whitened time-domain and time-frequency versions and to review previously marked events.

## 2 How to cite

Please cite Delphos using [Roehri et al., 2016] for the method and [Roehri et al., 2017] for the validation.



### 3 Requirements

- Delphos\_Viewer.zip: Zip folder containing Delphos Viewer plugin and required components,
- MCR\_R2018b\_win64\_installer.exe: Matlab Runtime Executable 2018b.

Delphos\_Viewer.zip must be unzip in C:\Documents\AnyWave\Plugins\Matlab\Delphos\_Viewer.

MCR\_R2018b\_win64\_installer will install a Matlab engine to run compiled code such as Delphos Viewer.



## 4 Usage

1. From AnyWave, click on the **Process** tab and then on **Matlab** and finally on **Delphos Viewer** (Fig. 2).

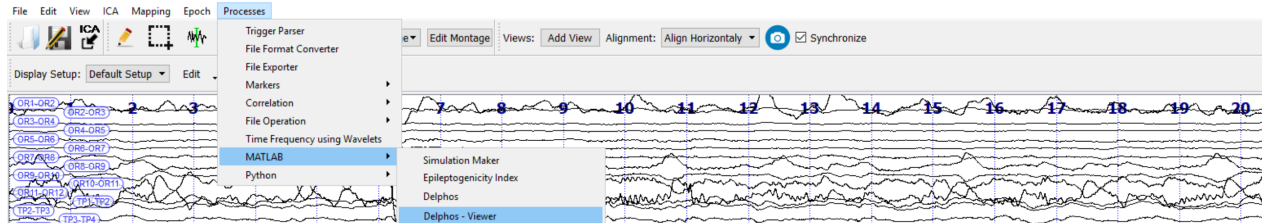


Figure 2: AnyWave Processes tab

Note that AnyWave continues running while Delphos is in use, this means AnyWave can be used normally and other calculations can be launched.

2. A splash screen (Fig. 1) pops up when AnyWave launches Delphos Viewer. The main interface (Fig. 3) should appear shortly after.

### 4.1 Main panel, Fig. 3 A

Delphos Viewer displays the trace of a single channel in time and time-frequency (TF) domain synchronously (Fig 3 A.). One can tune the parameters of the time-frequency analysis, filter the data in the time domain and move through time using the horizontal scrollbar. Interestingly, one can import markers from AnyWave, review them, and even add new markers (Markers panel in Fig 3 B.). It is also possible for the user to modify the axis of the traces and the color axis of the TF image (Axis panel in Fig 3 C.).

In the Detection panel (Fig 3 D.), the user can launch the detection procedure on the selected channel. The detections are represented in the TF axis as green circles for oscillations and red triangles for spikes. The marker list in the Marker panel is updated as soon as the detection stage finishes. By double-clicking on the marker, both the main AnyWave view and the viewer are centered on this detection.

The last panel (Extra panel in Fig 3 E.) allows verifying that the normalisation process worked out correctly. The top image corresponds to the histogram of the real part of the wavelet coefficients after normalisation. Each line should resemble the  $H_0$ -line. The bottom plot shows the estimation of the power spectrum of the background activity and the power spectrum of the current time-window.

In the following sub-section, the different panels available in Delphos Viewer are described.

### 4.2 Parameters Panel, Fig. 3 A

- **Select Channel:** select a channel within the list of channel send by AnyWave (corresponding to the current AnyWave montage or manual selection). By default, Delphos select the first channel of the list.

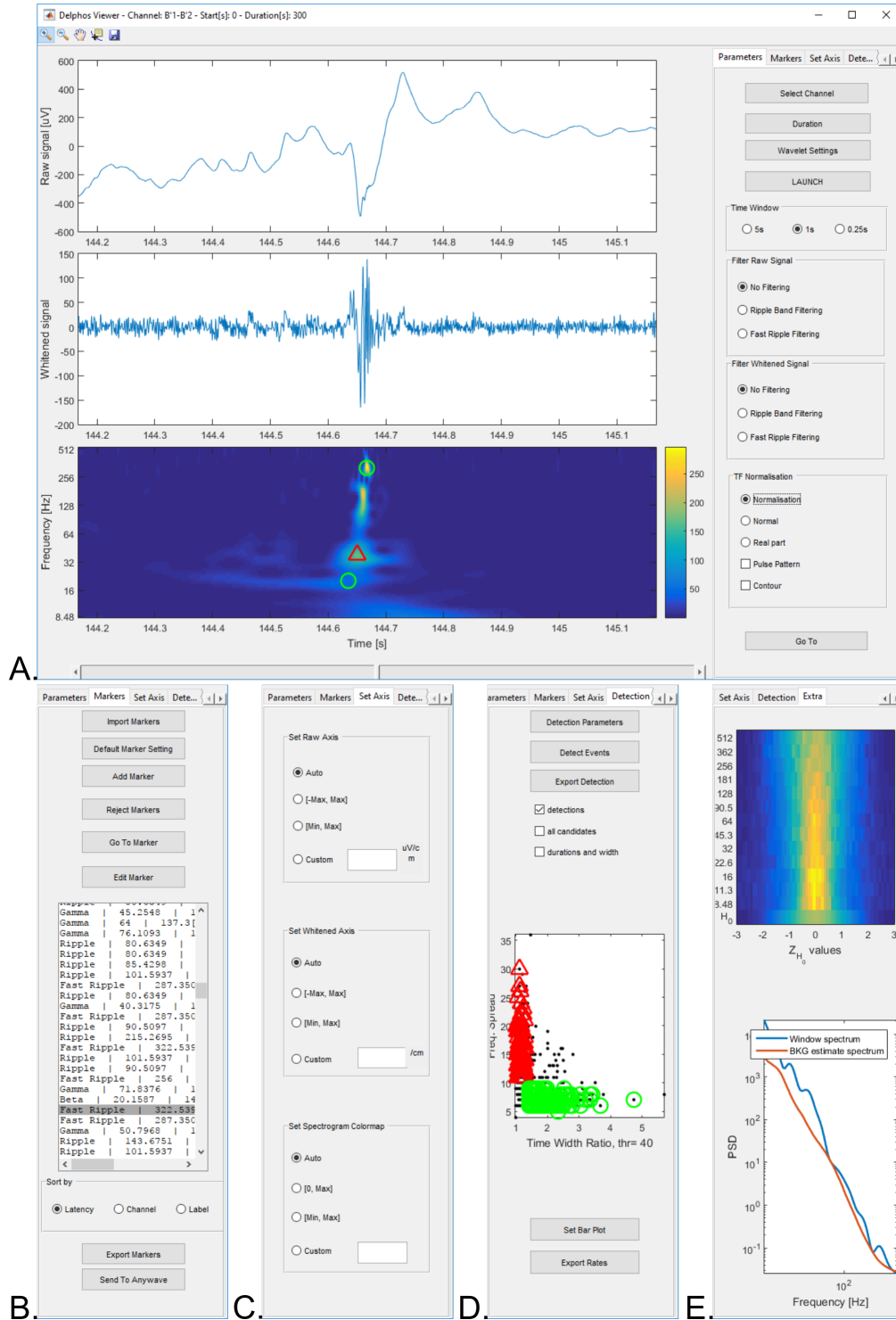


Figure 3: Delphos Viewer interface and the different panels. A. Main frame which displays the traces in original and whitened time domains above the whitened time-frequency image. The associated panel handles the parameters such as the channel selection or the filtering settings. B. Marker panel. C. Axis Setting panel. D. Detection panel. E. Extra panel for sanity check.



- **Duration:** set the beginning and duration (in seconds) of the section to be analysed. By default, Delphos analyses 5 minutes (duration = 300s) – or the duration of the file if shorter than 5 minutes – starting from the beginning (start = 0s). To tell Delphos to analyse the whole section you have to set start at 0 and write *all* in duration.
- **Wavelet Settings:**
  - the number of voices corresponds to the resolution of the time-frequency plane (similar to the frequency step in linear scale but in log-scale). Lowering the number of voices speeds up the analysis but lower the sensitivity of the detection.
  - the vanishing moment controls the time and frequency resolution of the wavelet. The greater, the higher the frequency resolution but the lower the time resolution.
- **Time window:** size of the time window displaying the different raw and transformed signals.
- **Filter Raw Signal:** panel to filter the raw signal. Set the filter to on to display the filtered signal.
- **Filter Whitened Signal:** panel to filter the whitened signal. Set the filter to on to display the filtered signal.
- **Time-frequency normalisation:** permits to switch between z-H0 normalisation and no normalisation. It is also possible to display the real part of the wavelet (instead of the usual power). The 'Pulse Pattern' allow displaying the impulse response of the wavelet transform. The 'Contour' button permits to show the iso-contour instead of all values.
- **Go To:** Permits to center the window at a specific timing in second.

### 4.3 Markers Panel, Fig. 3 B

- **Import Marker:** it imports the markers from AnyWave to Delphos Viewer.
- **Default Marker Setting:** set the label and value of the default marker used when a new marker is added manually.
- **Add Marker:** Add a new marker in the list. Click on any window with a time-series to set the timing. Make a drag-and-drop to set the duration.
- **Go To Marker:** Center the displayed window on the selected marker (in both Delphos - Viewer and AnyWave). Double clicking on a given marker in the marker list has the same effect.
- **Edit Marker:** Permit to modify the attributed of the selected marker.
- **Sort by:** It allows sorting the marker list according their latency, channel or label.
- **Export Markers:** Export the markers as AnyWave marker file (.mrk).
- **Send To AnyWave:** Send the markers from Delphos to AnyWave.

### 4.4 Set Axis Panel, Fig. 3 C

- **Set Raw Axis:** set the x-axis of the axis with the raw signal.
- **Set Whitened Axis:** set the x-axis of the axis with the whitened signal.
- **Set Scalogram Axis:** set the limit of the color map coding the time-frequency plane.



## 4.5 Detection Panel, Fig. 3 D

In the installation folder of Delphos Viewer(C:\Documents\AnyWave\Plugins\Matlab\Delphos\_Viewer), there is a file named *default\_freqband.txt* where default settings of the oscillations markers are set (label, color and frequency bands) in a semicolon separated file. The first column corresponds to the label of the oscillation, the second and third columns to its lower and higher limits of its frequency band respectively, and the last column to the color of the marker in hexadecimal. An example is given below:

```
%%Oscillation name;lower frequency;higher frequency
Very Fast Osc;500;Inf;#ff00ff
Fast Ripple;250;500;#ff0000
Ripple;80;250;#ff8000
Gamma;24;80;#800000
Beta;12.4;24;#00b000
Alpha;7.4;12.4;#00b0b0
Theta;3.5;7.4;#0070ff
Delta;1;3.5;#0000ff
Infra slow;0;1;#000090
```

- Detection Settings:
  - *Threshold* corresponds to the level in the ZH0 time-frequency image separating the background from an event of interest. Default is set to 40.
  - *Osc width thr* is the lowest time width defining an *oscillation*,
  - *Osc freq spread thr* is the highest frequency spread defining an *oscillation*,
  - *Spk width thr* is the highest time width defining a *spike*,
  - *Spk freq spread* is the lowest frequency spread defining a *spike*,
- Detect Events: launch Delphos detector on the selected channel. The detected events will populate the marker list.
- Export Detection: export the detection and/or the candidate events in Matlab file. Candidate events corresponds to events which exceeded the threshold but did not meet the other criteria.
- Set Bar Plot: Select the types of events you want to look at in the bar plot of the rates. The *default\_freqband.txt* file is used to define the name of the event type.
- Export Rates: Export the rates in an Excel file.

## 4.6 Extra Panel, Fig. 3 E

This panel permits to verify that the normalisation is done properly. The histograms (the counts are color coded) should be the same across frequencies. The power spectrum of the current window is displayed in blue in the bottom panel along with the estimated background power spectrum in orange.

## References

- [Roehri et al., 2016] Roehri, N., Lina, J.-M., Mosher, J. C., Bartolomei, F., and Bénar, C.-G. (2016). Time-frequency strategies for increasing high frequency oscillation detectability in intracerebral. *IEEE Transactions on Biomedical Engineering*, 63(12):2595–2606.
- [Roehri et al., 2017] Roehri, N., Pizzo, F., Bartolomei, F., Wendling, F., and Bénar, C.-G. (2017). What are the assets and weaknesses of HFO detectors? A benchmark framework based on realistic simulations. *PLoS ONE*, 12(4).