A signal analysis environment for MATLAB

GUI User Guide

M. Lidierth (2009). sigTOOL: a MATLAB-based environment for sharing laboratory-developed software to analyze biological signals. *Journal of Neuroscience Methods* **178**, 188-196.
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Future developments

To-date, sigTOOL has been developed with the support of the School of Biomedical and Health Sciences at King's College London. Further development, in particular from outside-funding agencies, will depend on how useful it is found by the wider neuroscience community. If you are a sigTOOL user you can help:

[1] Send feedback

Email bug reports, feature requests and any other feedback to sigtool@kcl.ac.uk

[2] Cite the sigTOOL paper

If you publish results from sigTOOL, please cite its use by including a reference to the sigTOOL paper. Please also cite any third-party software accessed via sigTOOL e.g.

"Spikes were detected and sorted using Wave_clus (Quiroga et al., 2004) running in sigTOOL (Lidierth, 2009)"

M. Lidierth (2009). sigTOOL: a MATLAB-based environment for sharing laboratory-developed software to analyze biological signals. Journal of Neuroscience Methods 178, 188-196.

R.Q.Quiroga, Z. Nadasdy & Y. Ben-Shaul (2004). Unsupervised spike detection and sorting with wavelets and superparamagnetic clustering,Neural Computation, 16, 1661-1687.

[3] Register

You can register as a sigTOOL user from the sigTOOL GUI. Registered users can also elect to subscribe and will receive an email when updates are posted. sigTOOL use is growing steadily. In the future, we may also produce a newsletter for distribution to subscribers which will include e.g. details of sigTOOL compatible software libraries developed by third-parties.

A note about sigTOOL

sigTOOL is an open source package for analying biological signals. It is a pre-release: sigTOOL is not a finished product. Also note that, with about 40000 lines of code, there are likely to be some bugs.

sigTOOL is supplied without warranty, without even the implied warranty of fitness for a particular purpose.

sigTOOL is available from SourceForge
http://sigtool.sourceforge.net

If you have a question about MATLAB programming, whether using sigTOOL or not, post it to the MATLAB Newsgroup at
http://www.mathworks.com/matlabcentral/newsreader/
If the question has a sigTOOL slant, attach 'sigTOOL' to the post as a keyword.

You can also email the author directly with sigTOOL-specific enquiries at sigtool@kcl.ac.uk.

Scope of this guide

The sigTOOL GUI User Guide provides an overview of the features available through the GUI. It does not give details about particular analyses – that information is contained in the online help.

When you see this symbol anywhere in sigTOOL, click on it to get to the relevant online help

Note
sigTOOL is evolving. Detailed features of the menus and GUIs shown in the figures of this document may have changed since they were included

Getting Started

Step 1:

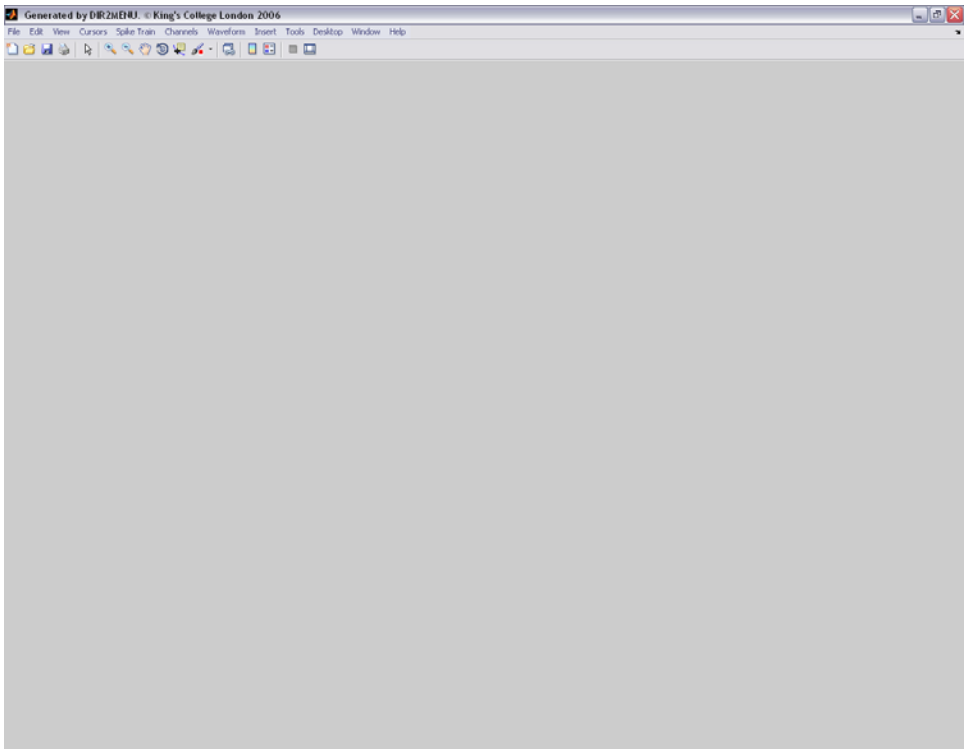
If you have not done so already, download the sigTOOL archive (zip file) from the website

Step 2:
Open the zip file and follow the instructions in the "Installing sigTOOL" pdf file.

Step 3:
Run MATLAB and type sigTOOL at the command prompt (make sure you have followed the installation steps to set up the MATLAB path)

You should see an empty sigTOOL data view like that shown below[1]:

[1] Exactly what you see will depend on the MATLAB version, the operating system and the Java Look and Feel on your PC.

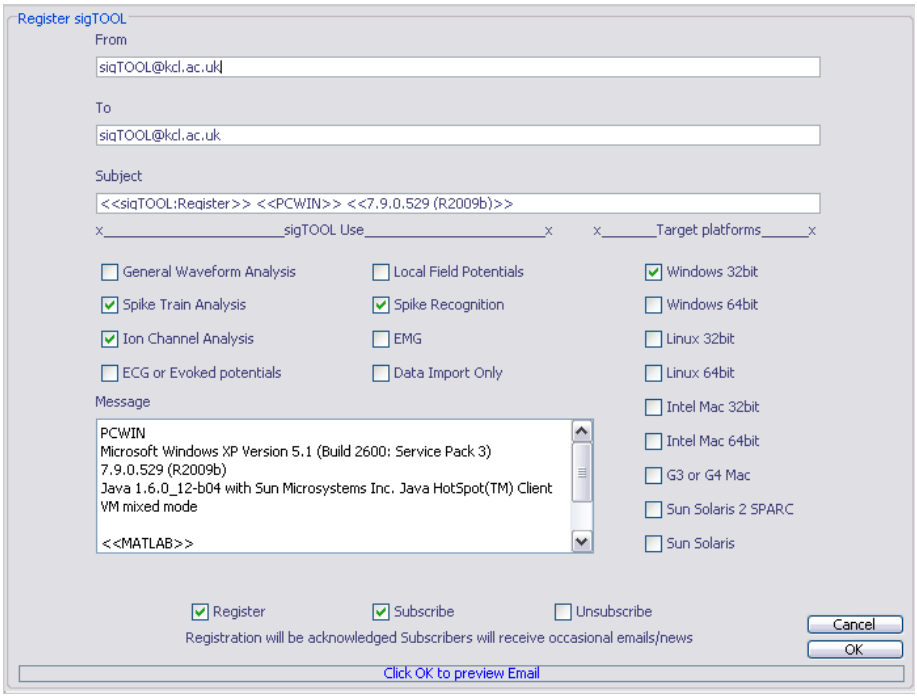

Generated by DIR2MENU. © King's College London 2006
File Edit View Cursors Spike Train Channels Waveforms Insert Tools Desktop Window Help

Step 3: Registering and subscribing

You do not need to register sigTOOL to use it but doing so will assist us to improve the software.

The sigTOOL GUI lets you register sigTOOL and subscribe to updates. Registration will help us to target further development of sigTOOL and to raise funds for that development.

In the sigTOOL GUI, select *Help -> sigTOOL-> Register sigTOOL*



Registered users will receive an acknowledgment but should receive no further emails

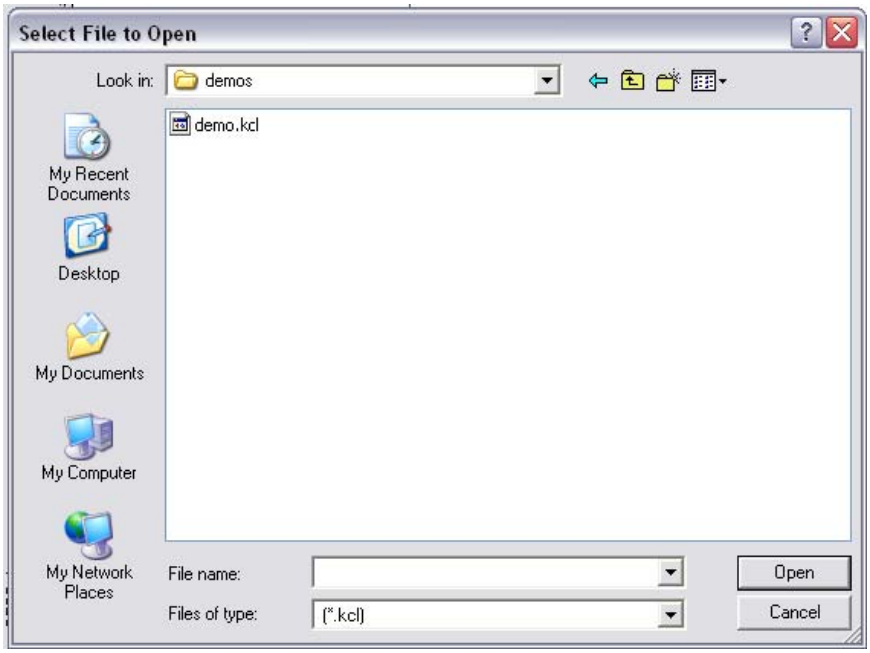
Subscribers will receive notification when updates of sigTOOL are posted to the SourceForge website and occasional news about sigTOOL.

Note that this is independent of any news/RSS feeds you may have set up from SourceForge.

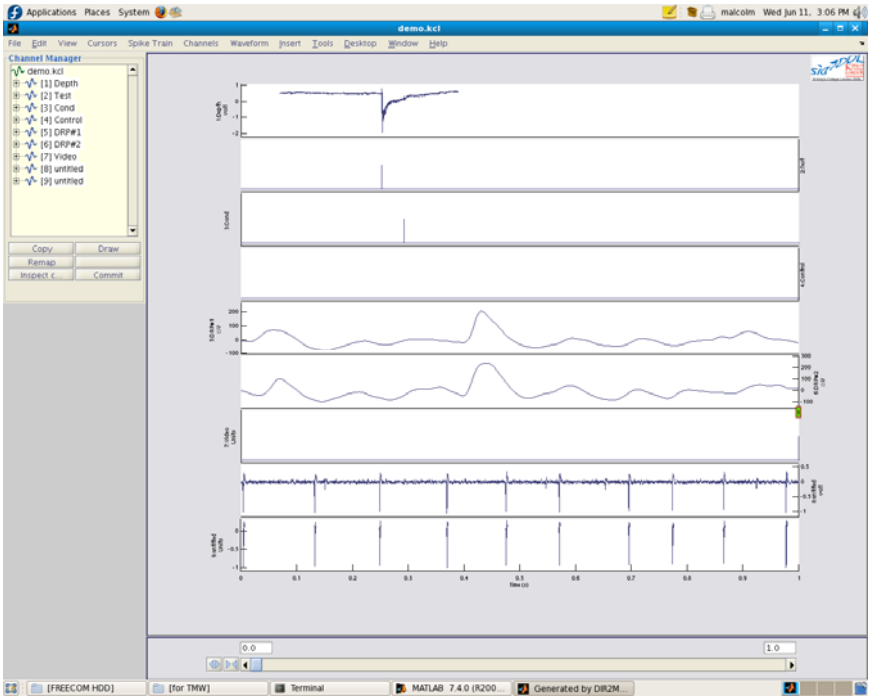
To **unsubscribe** subsequently, repeat the process selecting the unsubscribe check box

Step 4:
If you are running sigTOOL for the first time, select the ‘File’ menu and choose ‘Open’.

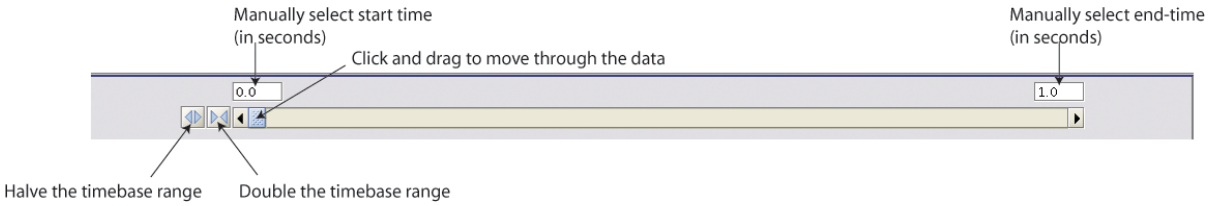
This will display the standard file open dialog for your system e.g. for Windows XP:



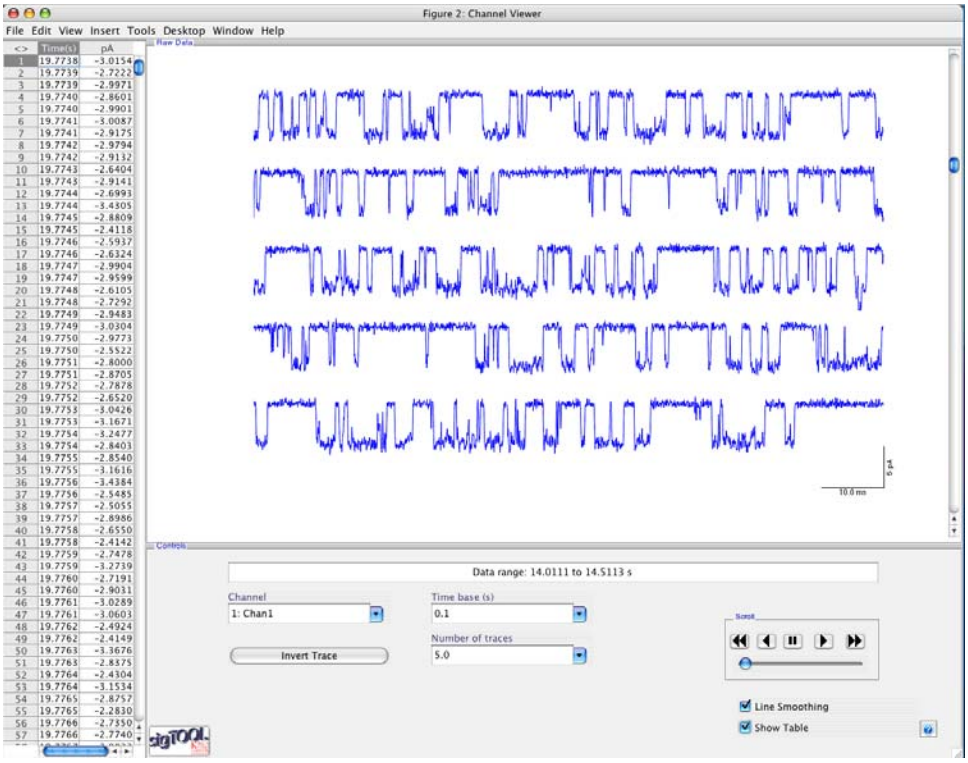
Navigate to the demonstration data file ‘demo.kcl’ which can be found in the .../sigTOOL/demos folder (as above).
Double-click on the file name and sigTOOL will display the data in a strip-chart style display as shown below (on Fedora 8 Linux).



You can scroll though the data and control the time base using the controls at the bottom of the figure window



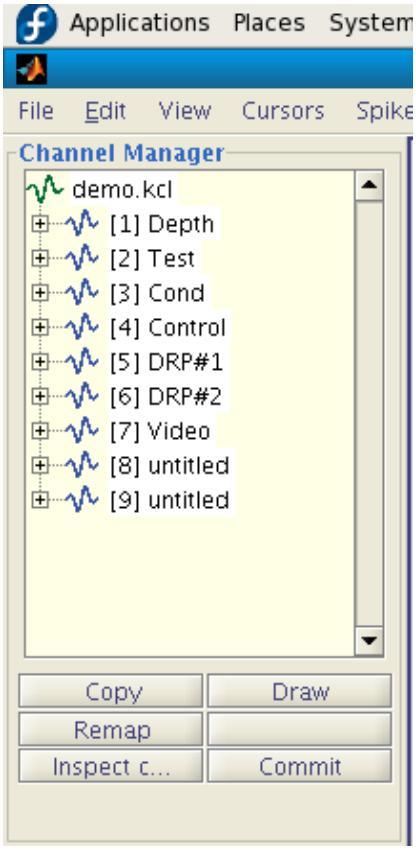
The standard sigTOOL data view is optimised to provide efficient memory use with large numbers of lengthy data channels. From Version 0.92 onwards, sigTOOL also provides a Channel Viewer that allows a single data channel to be viewed and scrolled through rapidly. This is under development and currently supports only continuously sampled waveform data. You can access the Channel Viewer by selecting *Waveform->Channel Viewer* in the main sigTOOL data view. The channel viewer is shown below on an Apple Mac PC.



Scroll through the data manually using the scrollbar to the right. Scroll automatically using the controls in the Control Panel. You can set the scroll speed using the slider in the scroll controls. You can select to smooth the lines and switch off the update to the data table on the left of the display using the checkboxes in the control panel.

Note that you are likely to get some screen flicker with this display as it scrolls.

The Channel Manager
To select the channels to draw use the Channel Manager



Select the channels you want using the mouse, then click **Draw**.

The other options in the Channel Manager are as follows:

Copy

Copies the selected channel numbers to the clip board. These can be pasted into the sigTOOL analysis GUIs. You can also just drag-and-drop the selections into these GUIs

Primarily for programmers rather than users, the following options are also available:

Remap

sigTOOL does not load channel data directly into memory. Instead, data are memory mapped through the operating system's virtual memory management. Virtual memory is managed dynamically by sigTOOL but if you still receive

out-of-memory errors you can force all memory to be released by clicking Remap. Remap acts on all channels in all open files, not just those selected in the menu.

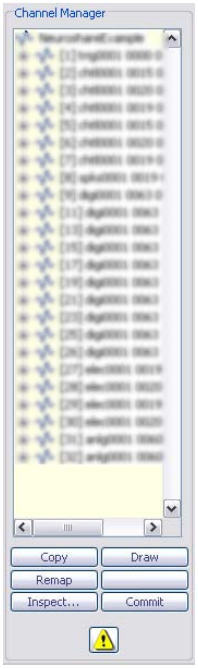
Commit

Commit replaces the virtual memory representation of the selected channels(s) with direct RAM based copies. This is probably only useful to programmers.

Inspect

Converts the channel data to a structure that is then opened in the MATLAB array editor for inspection

N.B. You can view the sigTOOL channel data but not edit it in the array editor.



You should never see this symbol:

in the Channel Manager. If you do, sigTOOL has detected problems in the loaded data file. Click the symbol to view details of those problems. These will be listed as ERRORS or WARNINGS. In either case the problem will lie in the import processes for the file format from which the data were derived.
For an explanation of the problems, type "helpwin scCheckChannels" at the MATLAB command line.

You should never see this symbol.
If your do.
[1] try reimporting the data with the latest version of sigTOOL (the issues may already have been addressed).
[2] If that does not resolve the problems, please email the original data file (not the sigTOOL file) to sigtool@kcl.ac.uk. **[or export a few seconds of data in the original format: that should be sufficient to isolate the problem].**

The File Menu

Open
Use the *File->Open* menu to open sigTOOL data file(s) as described above. Note that you can select multiple files to open.

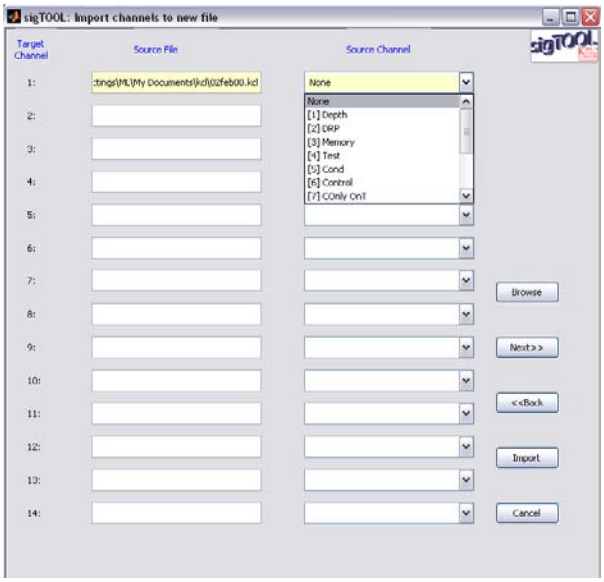
New
Select *File->New* to create a new sigTOOL data file with channels selected from pre-existing data files. This option can be used to create archive files, with channels selected from multiple source files.

When the *File->New* dialog is displayed:

1. Click on the Source File box for the channel you want to allocate. Click "Browse" and select a file using the system file browser.

2. Click on the Source Channel dialog, and select the channel you want to import from the drop down list.

Note that the path and filename of the last selected file is placed in the system clipboard. Just paste this filename into the next channel Source File selector if you want to import multiple channels from a single file.



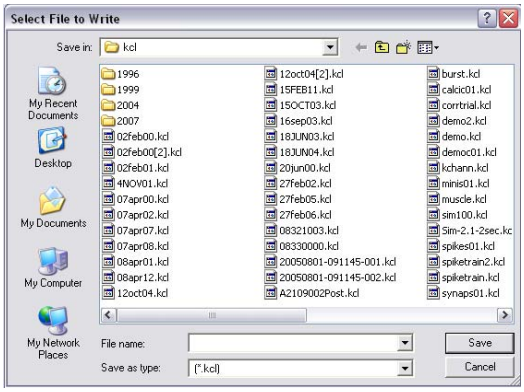
The Next and Back buttons can be used to scroll through multiple panels: there is no limit to the number of channels you can import. When all channels have been selected, click the Import button. This will create a new sigTOOL data file. To save this file, select *File->Save As* (as described below).

Load Result

Loads and displays an analysis result previously saved from a sigTOOL result view. Note that, at present, result files are not portable between platforms and may not be portable between PCs using the same OS.

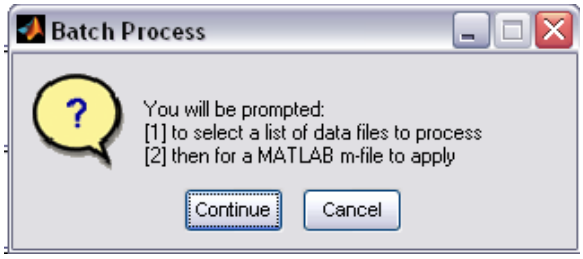
Save As

There is presently no Save function in sigTOOL. Any changes you make to a file must be saved with *File->Save As*.
After selecting *File->Save As*., the standard system file selector will be displayed. Use this to set the file name and path for the new file and click the Save button. Note that you can not re-use the name of a file that is currently open in sigTOOL/MATLAB.
Data files saved with *File->Save As* are portable between operating systems and PCs.

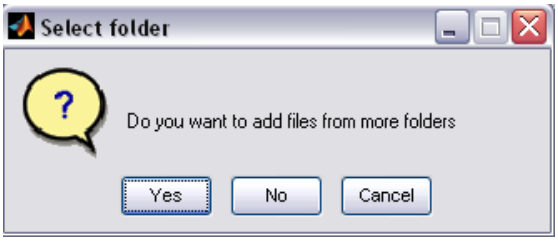


Batch Process

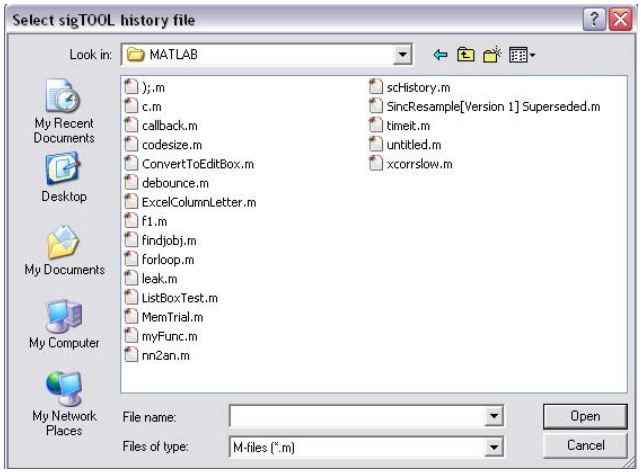
Batch processing of multiple data files can be accomplished using the *File-> Batch Process* option. Initially, this displays a guidance box:



Click the Cancel button if you do not want to proceed. Otherwise click Continue which will lead to a series of prompts to select the data files to process. First you will see the standard file open dialog for your system. Select one or more files to include in the batch list. You will then see:

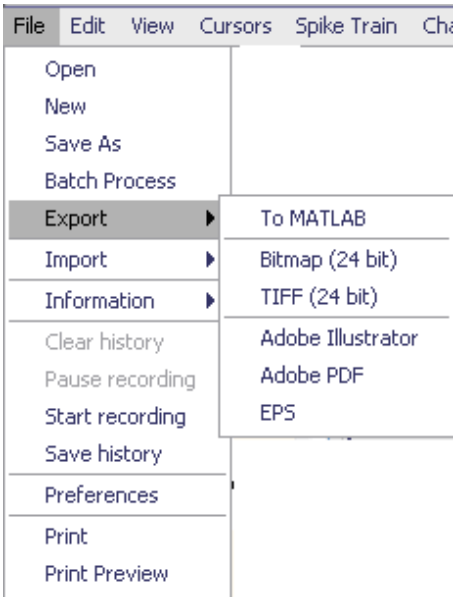


Choose Cancel to exit. Click Yes, to open another file dialog and add more data files. Click No to end file selection and choose a code file to execute. Typically this will be a sigTOOL history file recorded using *File->Start Recording* (see below)



Export

The *File->Export* menu allows the raw channel data to be exported.



Choose *Export -> To MATLAB* to copy the raw data from this sigTOOL data file to the MATLAB base workspace. The data will be placed in a variable called 'channels' which will be a cell array of scchannel objects. For further details of this, see the sigTOOL Programmer's Guide.

The remaining options cause the current data view to be exported to a file in a graphics format suitable for use in other programs. Two pixel-based formats are available (bitmapped – BMP and tagged image – TIF). In addition, you can use a vector format (Adobe Illustrator, Adobe Portable Document Format (PDF) or Encapsulated Postscript (EPS)).

On Windows, the generated file will be opened using an appropriate graphics utility (if Windows has been set up to recognize the file format).

Fast Save and Fast Open

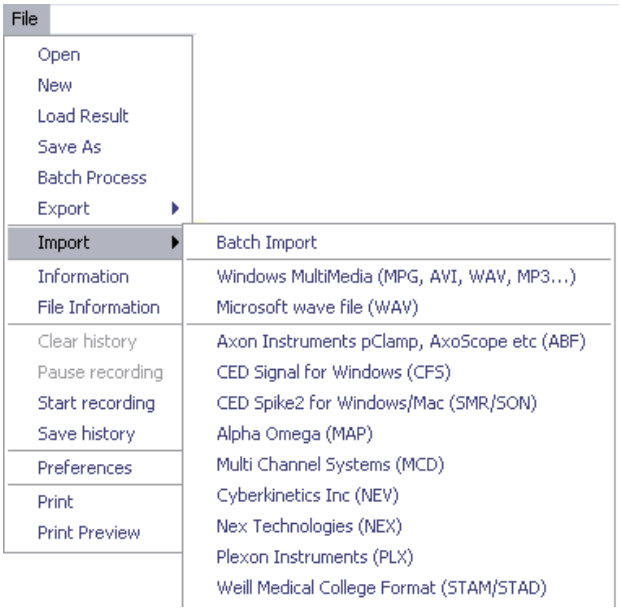
File->Fast Save can be used to back-up your work in the short term. *File->Fast Save*.creates a temporary file that includes:
[1] Information about the raw data associated with a data view
[2] Settings for the view including, for example, cursor positions
[3] Any analysis results from the data view that are open.
Reloading the file using *File->Fast Open* will restore the data and analysis views.

Fast Save is quick because it saves sigTOOL objects, rather than raw data. However, because those objects may contain absolute path information for the source data files, Fast Saved files are not transferable between operating systems or PCs.

Some source files may be temporary files in the system temporary folder created by sigTOOL. Running a disc clean (or sigTOOL('cleanup') will make Fast Saved sigTOOL files unusable.

When using *File->Fast Open*, sigTOOL will refuse to reload Fast Saved files if:
[1] You are not on the same PC
[2] Any source files are missing
[3] Any source files have changed since the Fast Save was performed

Import



Multimedia formats are supported via Micah Richert's[2] mmread import function for both sound and video formats (e.g. WAV, MPG, AVI).

The neuroscience formats shown above are supported via the sigTOOL Neuroscience Toolkit which needs to be installed for these options to be present.

To import a file, select the appropriate format. The standard system file dialog will appear. sigTOOL will import the file creating a sigTOOL data file with the .kcl extension. This will then be displayed in a sigTOOL data view.

Batch Import allows the import of multiple files, from multiple folders using multiple formats in one go. When using Batch Import, the imported files will not be opened. Use File->Open to view them.

[2] This needs to be downloaded separately from http://www.mathworks.com/matlabcentral/fileexchange/loadFile.do?objectId=8028&objectType=file

File Information

File -> File Information presents a summary of the channel information in a table

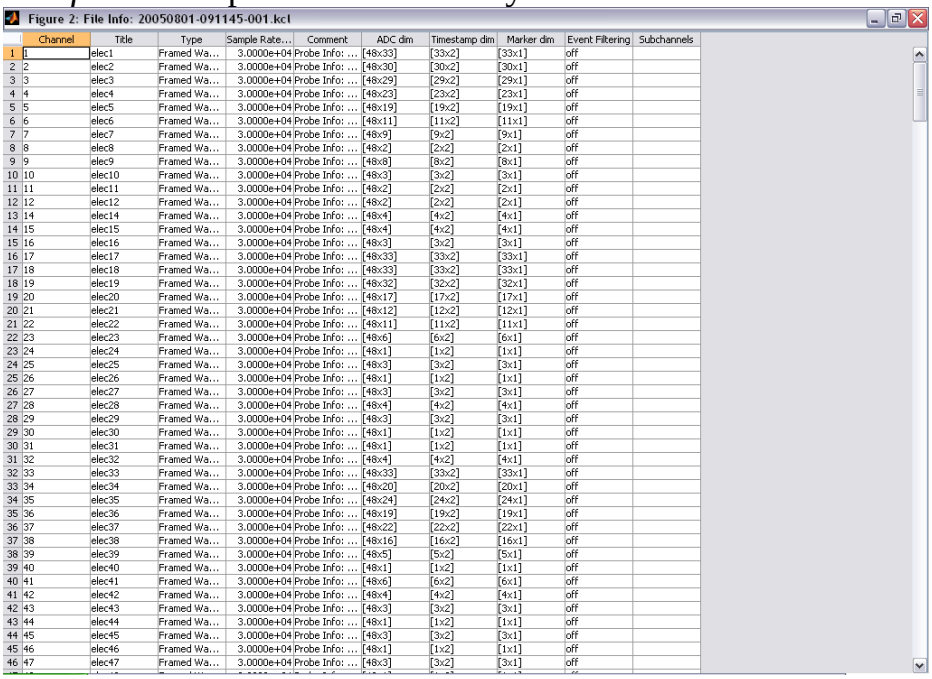


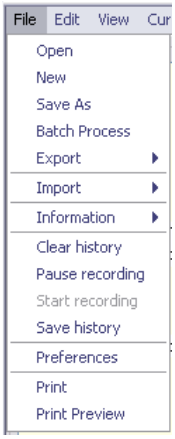
Figure 2: File Info: 20050801-091145-001.kcl

	Channel	Title	Type	Sample Rate...	Comment	ADC dim	Timestamp dim	Marker dim	Event Filtering	Subchannels
1	1	elec1	Framed Wa...	3.0000e+04	Probe Info: ...	[48x33]	[33x2]	[33x1]	off	
2	2	elec2	Framed Wa...	3.0000e+04	Probe Info: ...	[48x30]	[30x2]	[30x1]	off	
3	3	elec3	Framed Wa...	3.0000e+04	Probe Info: ...	[48x29]	[29x2]	[29x1]	off	
4	4	elec4	Framed Wa...	3.0000e+04	Probe Info: ...	[48x23]	[23x2]	[23x1]	off	
5	5	elec5	Framed Wa...	3.0000e+04	Probe Info: ...	[48x19]	[19x2]	[19x1]	off	
6	6	elec6	Framed Wa...	3.0000e+04	Probe Info: ...	[48x11]	[11x2]	[11x1]	off	
7	7	elec7	Framed Wa...	3.0000e+04	Probe Info: ...	[48x9]	[9x2]	[9x1]	off	
8	8	elec8	Framed Wa...	3.0000e+04	Probe Info: ...	[48x2]	[2x2]	[2x1]	off	
9	9	elec9	Framed Wa...	3.0000e+04	Probe Info: ...	[48x8]	[8x2]	[8x1]	off	
10	10	elec10	Framed Wa...	3.0000e+04	Probe Info: ...	[48x3]	[3x2]	[3x1]	off	
11	11	elec11	Framed Wa...	3.0000e+04	Probe Info: ...	[48x2]	[2x2]	[2x1]	off	
12	12	elec12	Framed Wa...	3.0000e+04	Probe Info: ...	[48x2]	[2x2]	[2x1]	off	
13	14	elec14	Framed Wa...	3.0000e+04	Probe Info: ...	[48x4]	[4x2]	[4x1]	off	
14	15	elec15	Framed Wa...	3.0000e+04	Probe Info: ...	[48x4]	[4x2]	[4x1]	off	
15	16	elec16	Framed Wa...	3.0000e+04	Probe Info: ...	[48x3]	[3x2]	[3x1]	off	
16	17	elec17	Framed Wa...	3.0000e+04	Probe Info: ...	[48x33]	[33x2]	[33x1]	off	
17	18	elec18	Framed Wa...	3.0000e+04	Probe Info: ...	[48x33]	[33x2]	[33x1]	off	
18	19	elec19	Framed Wa...	3.0000e+04	Probe Info: ...	[48x32]	[32x2]	[32x1]	off	
19	20	elec20	Framed Wa...	3.0000e+04	Probe Info: ...	[48x17]	[17x2]	[17x1]	off	
20	21	elec21	Framed Wa...	3.0000e+04	Probe Info: ...	[48x12]	[12x2]	[12x1]	off	
21	22	elec22	Framed Wa...	3.0000e+04	Probe Info: ...	[48x11]	[11x2]	[11x1]	off	
22	23	elec23	Framed Wa...	3.0000e+04	Probe Info: ...	[48x6]	[6x2]	[6x1]	off	
23	24	elec24	Framed Wa...	3.0000e+04	Probe Info: ...	[48x1]	[1x2]	[1x1]	off	
24	25	elec25	Framed Wa...	3.0000e+04	Probe Info: ...	[48x3]	[3x2]	[3x1]	off	
25	26	elec26	Framed Wa...	3.0000e+04	Probe Info: ...	[48x1]	[1x2]	[1x1]	off	
26	27	elec27	Framed Wa...	3.0000e+04	Probe Info: ...	[48x3]	[3x2]	[3x1]	off	
27	28	elec28	Framed Wa...	3.0000e+04	Probe Info: ...	[48x4]	[4x2]	[4x1]	off	
28	29	elec29	Framed Wa...	3.0000e+04	Probe Info: ...	[48x3]	[3x2]	[3x1]	off	
29	30	elec30	Framed Wa...	3.0000e+04	Probe Info: ...	[48x1]	[1x2]	[1x1]	off	
30	31	elec31	Framed Wa...	3.0000e+04	Probe Info: ...	[48x1]	[1x2]	[1x1]	off	
31	32	elec32	Framed Wa...	3.0000e+04	Probe Info: ...	[48x4]	[4x2]	[4x1]	off	
32	33	elec33	Framed Wa...	3.0000e+04	Probe Info: ...	[48x33]	[33x2]	[33x1]	off	
33	34	elec34	Framed Wa...	3.0000e+04	Probe Info: ...	[48x20]	[20x2]	[20x1]	off	
34	35	elec35	Framed Wa...	3.0000e+04	Probe Info: ...	[48x24]	[24x2]	[24x1]	off	
35	36	elec36	Framed Wa...	3.0000e+04	Probe Info: ...	[48x19]	[19x2]	[19x1]	off	
36	37	elec37	Framed Wa...	3.0000e+04	Probe Info: ...	[48x22]	[22x2]	[22x1]	off	
37	38	elec38	Framed Wa...	3.0000e+04	Probe Info: ...	[48x16]	[16x2]	[16x1]	off	
38	39	elec39	Framed Wa...	3.0000e+04	Probe Info: ...	[48x5]	[5x2]	[5x1]	off	
39	40	elec40	Framed Wa...	3.0000e+04	Probe Info: ...	[48x1]	[1x2]	[1x1]	off	
40	41	elec41	Framed Wa...	3.0000e+04	Probe Info: ...	[48x6]	[6x2]	[6x1]	off	
41	42	elec42	Framed Wa...	3.0000e+04	Probe Info: ...	[48x4]	[4x2]	[4x1]	off	
42	43	elec43	Framed Wa...	3.0000e+04	Probe Info: ...	[48x3]	[3x2]	[3x1]	off	
43	44	elec44	Framed Wa...	3.0000e+04	Probe Info: ...	[48x1]	[1x2]	[1x1]	off	
44	45	elec45	Framed Wa...	3.0000e+04	Probe Info: ...	[48x3]	[3x2]	[3x1]	off	
45	46	elec46	Framed Wa...	3.0000e+04	Probe Info: ...	[48x1]	[1x2]	[1x1]	off	
46	47	elec47	Framed Wa...	3.0000e+04	Probe Info: ...	[48x3]	[3x2]	[3x1]	off	

Start Recording

File->Start Recording causes sigTOOL to record a history. This can be used to replicate user actions when batch processing data files.

Choosing *File->Start Recording* activates the remaining history functions: *Clear History*, *Pause Recording* and *Save History*.



Pause Recording

Choosing *File->Pause Recording* turns recording off until *File->Start Recording* is selected again.

Clear History

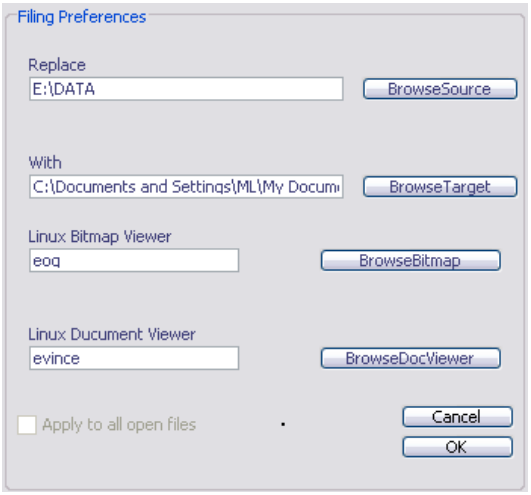
File->Clear History clears the history record.

Save History

File->Save History displays the standard system file creation dialog. Save the history as a MATLAB m-file. This code file can be used as an input when using *File-> Batch Process* as described above.

Preferences

File->Preferences displays a dialog to edit some sigTOOL variables. At present these are limited.



- **Replace/With**

This dialog allows you to set the default path for saving imported sigTOOL data files. With the settings shown above, when any source data file is imported from E:\DATA (or any subfolder of it), the resulting sigTOOL data file will be saved in C:\Documents and Settings\ML\kcl (or a subfolder of it). For example, if you were to import:

E:\DATA\2008\Jan\31\31jan00.smr

the resulting sigTOOL data file would be

C:\Documents and Settings\ML\kcl\2008\Jan\31\31jan00.kcl

- **Linux Bitmap/Document Viewer**

These set the Linux application that will be used to view sigTOOL outputs in graphical formats. The bitmap viewer will be used for pixel-based graphics (BMP & TIF) and the document viewer for vector graphics (PDF & EPS). The string entered here should be the command line string to invoke the application from Linux. The defaults are ‘eog’ for bitmap, and ‘evince’ for vector formats.

Print/Print Preview

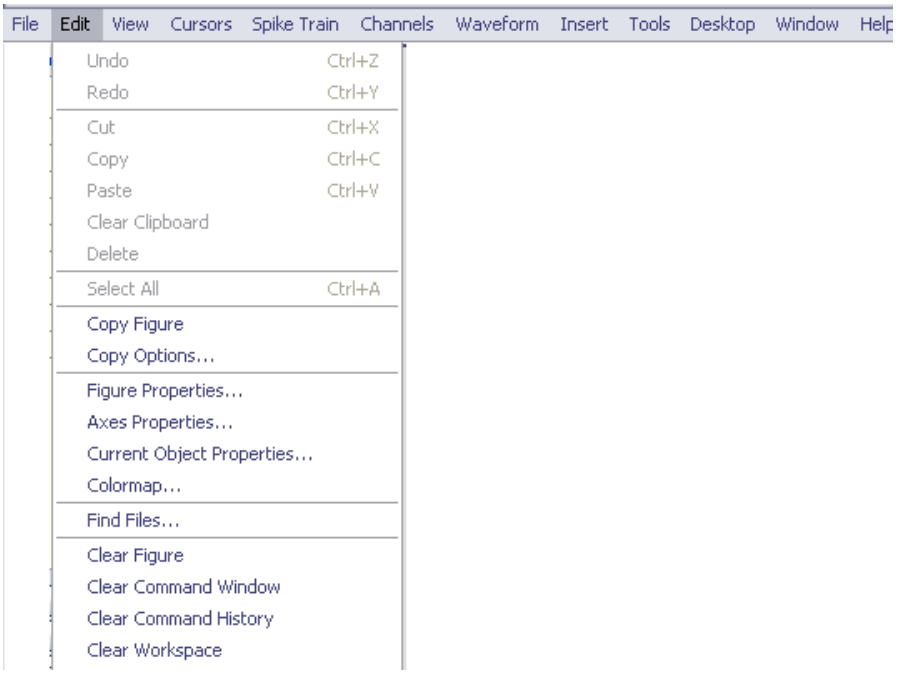
File->Print sends the current data view to the printer, displaying the default print selection dialog.

File->Print Preview displays a print preview and allows you to edit printing options.

The Edit Menu

The Edit menu in a sigTOOL data view is the standard MATLAB edit menu. At the time of writing, none of these commands have been altered – you should see MATLAB's default behaviour when selecting any of these options. For further details see the MATLAB documentation.

The example below shows the menu with MATLAB R2008a and Windows XP.



The View menu

The View menu is likely to expand in future releases. For the present it offers just 3 menu selections:

Refresh Hi Res
By default, sigTOOL pre-processes channel data to reduce the time taken to render graphics. This pre-rendering is dependent on the resolution of your computer screen. Select Refresh Hi Res to render the graphics without this pre-processing. This will make no difference to the screen image but may improve the quality of the output to other devices.

Smooth Lines/Jagged Lines
Toggles the display between an anti-aliased, soft-focus style and sharp lines. This behaviour will depend on the OpenGL software/hardware available on your computer. Use line smoothing to output bitmapped graphics to low-level graphics software if you want a less bitty appearance: professional graphics packages will generally have much better anti-aliasing packages built in.

Remove Text/Restore Text
Toggles the labeling of event data and epoch marker values.

The Cursor menu

Cursors can be used to select times in the analysis routine GUIs. More cursor functions will be included in later versions of sigTOOL.

Functions include:

New Cursor	create a new cursor
Delete All	delete all cursors
Load Cursors	load cursors from a previously saved file
Save Cursors	save the current cursor positions to a file

Cursor data files are standard MATLAB data files (with the .mat extension).

Note: to delete a specific cursor, right-click on it and select ‘delete’.

The Channels menu

The Channels menu provides functions for selecting events or data epochs and for selecting the subchannel for analysis from multiplexed data channels

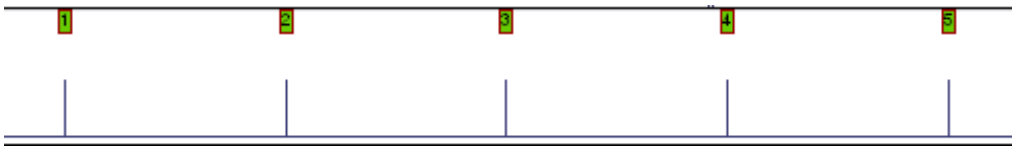
Data organization in sigTOOL

To understand the Channels menu, you need to know a little about how channel data are organized in sigTOOL.

The simplest data type is an event channel where the timestamps of discrete events are stored. These might be stimulus markers for example.

The channel type might be ‘Rising Edge’, ‘Falling Edge’ or just ‘Edge’.

Next we can associate each event with some data. The events above might be synch pulses from a video camera for example. The demo.kcl file includes an example of this.



You can view the data associated with each synch pulse by clicking on the green numbered squares. The numbers are the marker values for each event. In this case, the markers are the video frame numbers. In other circumstances the markers might be a code representing, for example, test and control stimuli where these were alternated during an experiment.

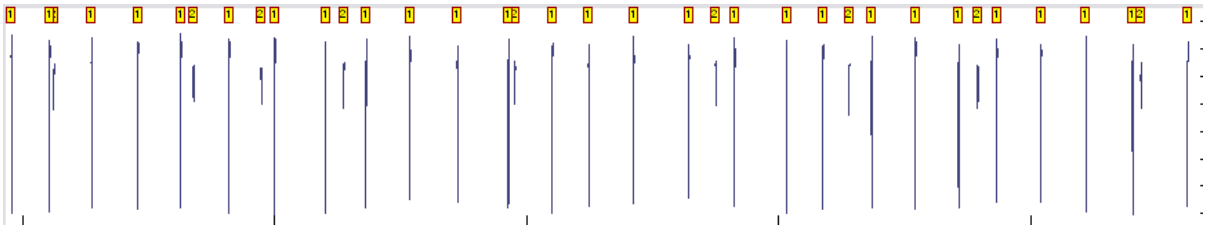
We have identified the three main components of a sigTOOL channel.

1. Timestamps associated with events
2. Data associated with each event
3. Marker data to classify the events

We can also associate more than one timestamp with each event:

In this case we record both the rising and the falling edges and the channel type is ‘Pulse’. Each pair of timestamps defines an episode of time. We can then associate an epoch of data with this period e.g. waveform data from a single oscilloscope sweep. In sigTOOL, the waveform data will then be plotted rather than the pulse. This is an ‘Episodic Waveform’

We can also associated markers with each epoch. In the case below these markers identify the spike of a single neurone in a multi-unit recording:



The markers can be single values or vectors of numbers, usually integers. The marker data can be more complex however, and include strings or structures perhaps containing metadata.

What if data are sampled continuously? That is just a special case where we have only one data epoch with one timestamp at the start of sampling and another at its end.

Finally we may need to associate a specific trigger time with the episodic data. In that case we just store three timestamps: the first marks the start of sampling for an epoch, the second marks the trigger time and last marks the end of sampling for each epoch. These channels are of two types:

1. Where there is no fixed temporal relationship between the three timestamps in different epochs. The epochs may vary in length and the length of sample before and after the trigger can be variable. These are labeled as ‘Episodic Waveform’ channels as before.
2. The temporal relationship is constant. All epochs are of the same length and there is a constant pre- and post- stimulus sample length. In this special case, the channel is labeled as a ‘Framed Waveform’.

Some file types allow multiplexed data to be stored on a single channel. In sigTOOL, these channels are stored just as above and the subchannels are interlaced in the data array. Most sigTOOL analysis routines do not support multiplexed data but the subchannels can be extracted to a channel of there own as described below.

The very simple channel organization described above is versatile enough to represent pretty much any waveform data. As shown above, it can also be used to represent other data formats such as video. To customize the treatment of non-waveform data the ‘Custom’ keyword is include in the channel type description and the file import function associates a MATLAB m-file function with the channel to process the data. For the video channel in demo.kcl this is the scViewImageData function. This displays the image when you click on the markers in the sigTOOL data view. Other functions could be defined to process any other type of data. For example, if you wanted to embed electronic notes in a file you could associate them with a timestamp placed at some appropriate point in the file. Place the text associated with the note in the data field and define a custom function to display the

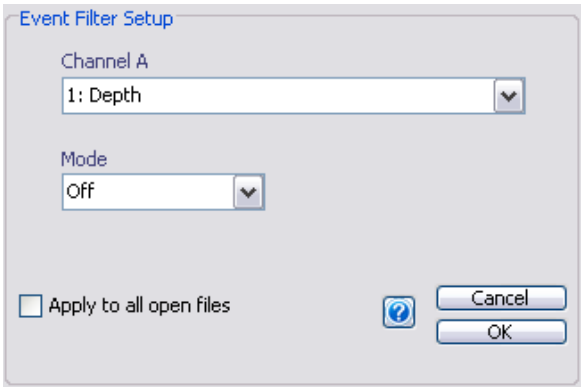
text in an editor when the marker is clicked. If the text was in a mark-up language, you could open it in the system web browser and include graphics or hyperlinks to web sites or other documents e.g. PDF files.

Event Filtering

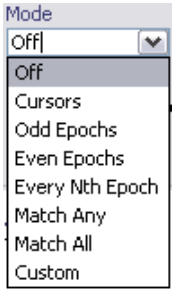
Event Filtering allows sigTOOL to select which events or epochs of data to include in an analysis. Typically, Event Filtering will be applied to the reference or trigger channel in an analysis (the Channel A selection, see below).

For each channel, Event Filtering can be switched on or off. When off, all events or epochs from that channel will be used in the sigTOOL analysis functions. When Event Filtering is switched on, only those events or epochs that are flagged as valid will be used: each event or epoch has a flag and this is either false (0) or true (1).

To set the flags choose the *Channels->Event Filter* menu. The following GUI will be displayed:



Choose the channel and select the Mode that you want.



The pre-defined Modes are:

Off

No event filtering is implemented on the selected channel

Cursors

'Cursors' selects those events/epochs that fall between pairs of cursors in the parent data view. A pair of cursors has one odd-numbered cursor (number n) and an even numbered cursor (n+1), e.g. 1+2, 3+4 etc. Missing or incomplete pairs will be ignored. For episodic waveforms, the entire epoch must be contained within the cursor pair.

The following selections select events/epochs according to their order.

Odd Epochs

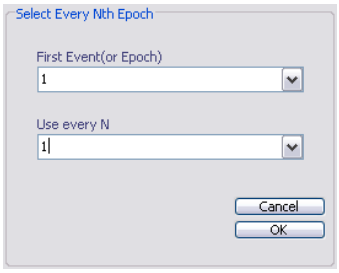
The first and every second subsequent event/epoch will be set valid.

Even Epochs

The 2nd and every second subsequent event/epoch will be set valid

Every Nth Epoch

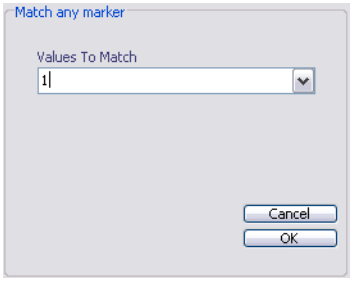
This will display a secondary GUI. Select the first event/epoch to use and the value for N. The first and every Nth subsequent event/epoch will be set valid



You can also select events/epochs based on the data in the marker field of each event/epoch

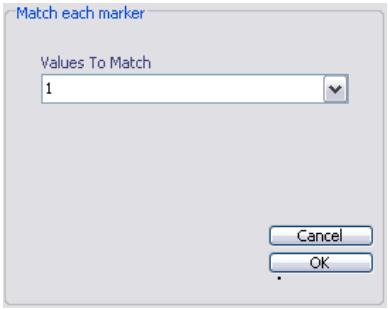
Match Any

Displays a GUI. Enter the numeric values you wish to match. If the event/epoch marker values contain any of the selected values, that event/epoch will be set valid.



Match All

Displays a GUI. Enter the numeric values you wish to match. If the event/epoch marker values exactly match the indicated values, that event/epoch will be set valid. If the markers are a vector, the vector entered in the menu must be exactly matched, element by element.

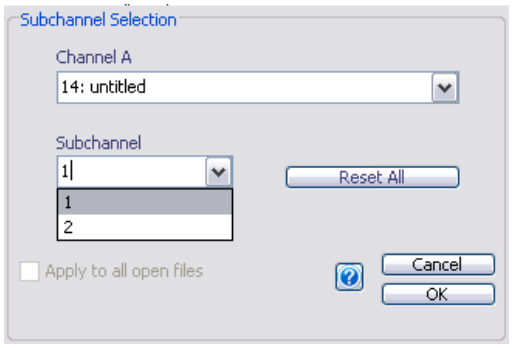


Custom

Displays a standard file opening dialog. Select a custom-written MATLAB m-file to return the true/false flags for the channel based on custom criteria (see the sigTOOL Programmer's Manual for further details).

Select Subchannel

To select a subchannel on a multiplexed channel use the *Channels->Select subchannel* menu. This display the following dialog:



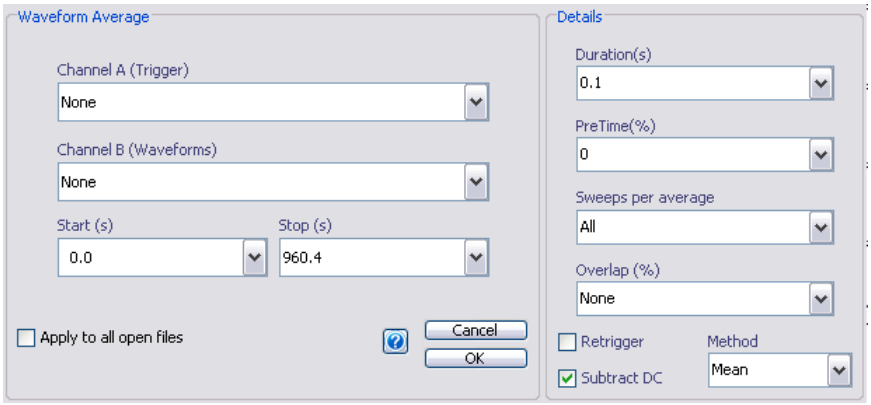
Select the target channel in the Channel A selector, then select the subchannel from the displayed list. The Reset All button resets the subchannel selection to 1 for all multiplexed channels in the file.

sigTOOL analysis functions do not generally accept multiplexed channels as input. To extract the selected subchannel to a channel of its own use select the *Waveform* menu followed by the *Copy channel*, *Digital Filter* or *Decimate* options. These respect the subchannel setting (as well as the Event Filter settings) for the source channel.

Analyzing data

Data analysis in sigTOOL is achieved by selecting one of the data analysis menus from a data view. The Waveform analysis menu is provided as standard. You may also see a Spike menu if the Neuroscience Toolkit is installed.

When you select an analysis option, e.g. *Waveform->Average*, a GUI similar to that below will appear:



The GUIs have several features in common

A main box on the left allows channel and time selection for the subsequent analysis:

Channel A selection

The Channel A selection lets you choose the trigger or reference channels for two-channel analyses (as above) or the source channels for one-channel analyses. Click on the drop down menu to select a channel or type a channel number (or set of numbers e.g. 1 2 5). You can also cut-and-paste or drag-and-drop your channel selection from the data view Channel Manager.

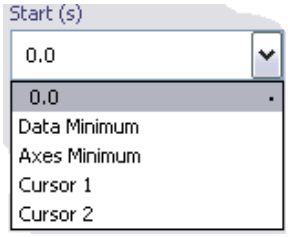
Channel B Selection

For two-channel analyses, the Channel B selected is the source channel or list of source channels. Select these as for the Channel A selection above.

Start and Stop

You can restrict the analysis to a particular time period by choosing start and stop. These are set in seconds. By default, these are set to zero and the end-of-file time (i.e usually the Data Minimum and the Data Maximum respectively). The drop-down menu allows other choices: The

minimum or maximum time currently displayed on the data view, or the time of a selected cursor:



Apply to all open files
If this box is checked as selected, the analysis will be applied to all sigTOOL data files currently open in any instance of MATLAB. You will need to ensure that the selections for channel triggers and sources make sense for each file and that data are available in the selected period.

In addition to the main menu, a secondary menu is also generally displayed, although for simple analyses the options may be integrated into the main menu. For the averaging analysis, the secondary menu is simply labeled “Details”.

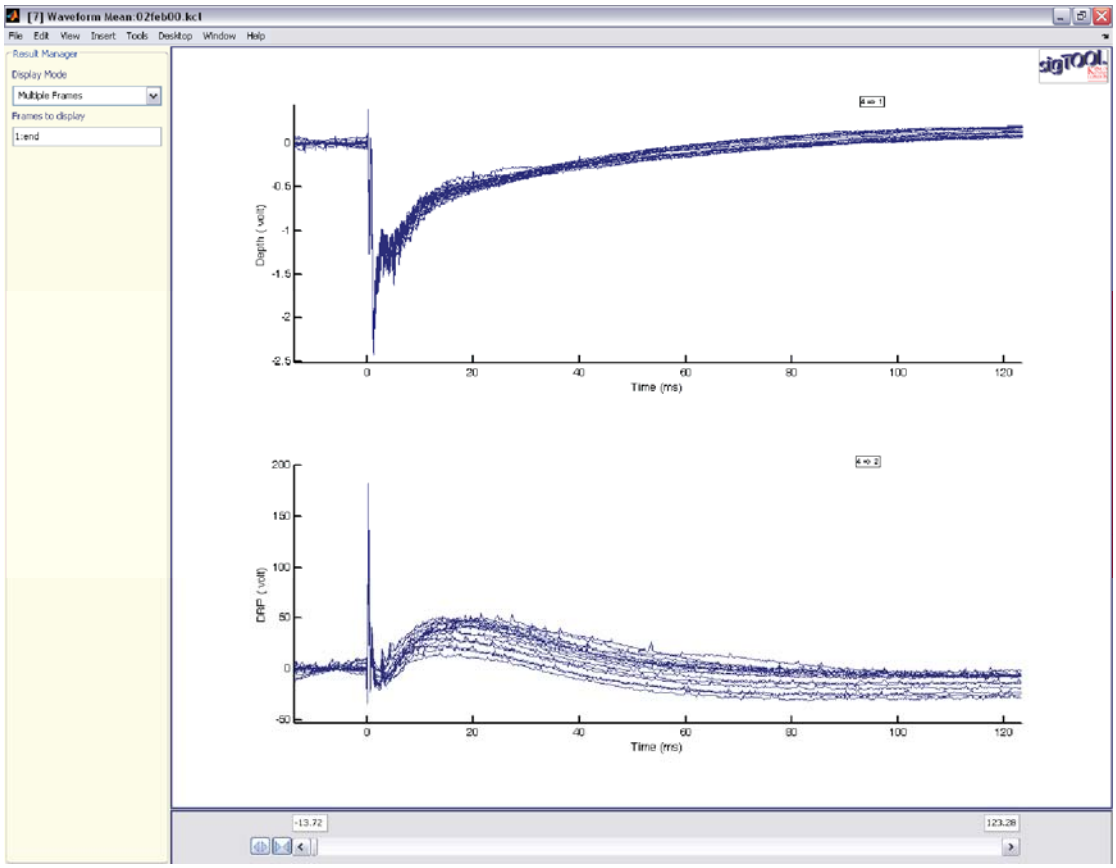
To obtain further information about both the main menu and the detailed options for any analysis, select in the main menu. This will display the on-line help for that analysis in the web browser e.g. for the average menu above:

Working with the results of analyses

sigTOOL calculates the results and displays them graphically once you click ‘OK’ in an analysis menu.

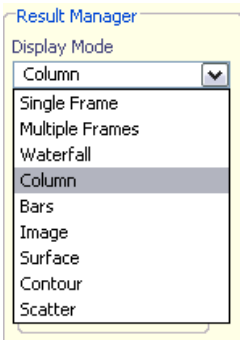
The description below applies to a standard result view. From sigTOOL version 0.89 onwards, non-standard custom-objects can be displayed in a result view. For these objects, some facilities may be turned off. However, custom-defined facilities for those displays can be accessed by double-clinking the mouse or right-clicking on them (N.B. on Windows – for equivalent mouse operations on other operating systems see the MATLAB documentation)

In the example below, the result of averaging two channels with a common trigger channel are shown. For each channel, 16 averages were calculated each consisting of 20 sweeps. By default, these are shown overlapped. The boxed numbers on each set of axes identifies the channel used: the first number gives the trigger or reference channel, the 2nd gives the source channel. If the number has a decimal place, that identifies the subchannel on a multiplexed channel e.g. 2.1 for subchannel 1 of channel 2.

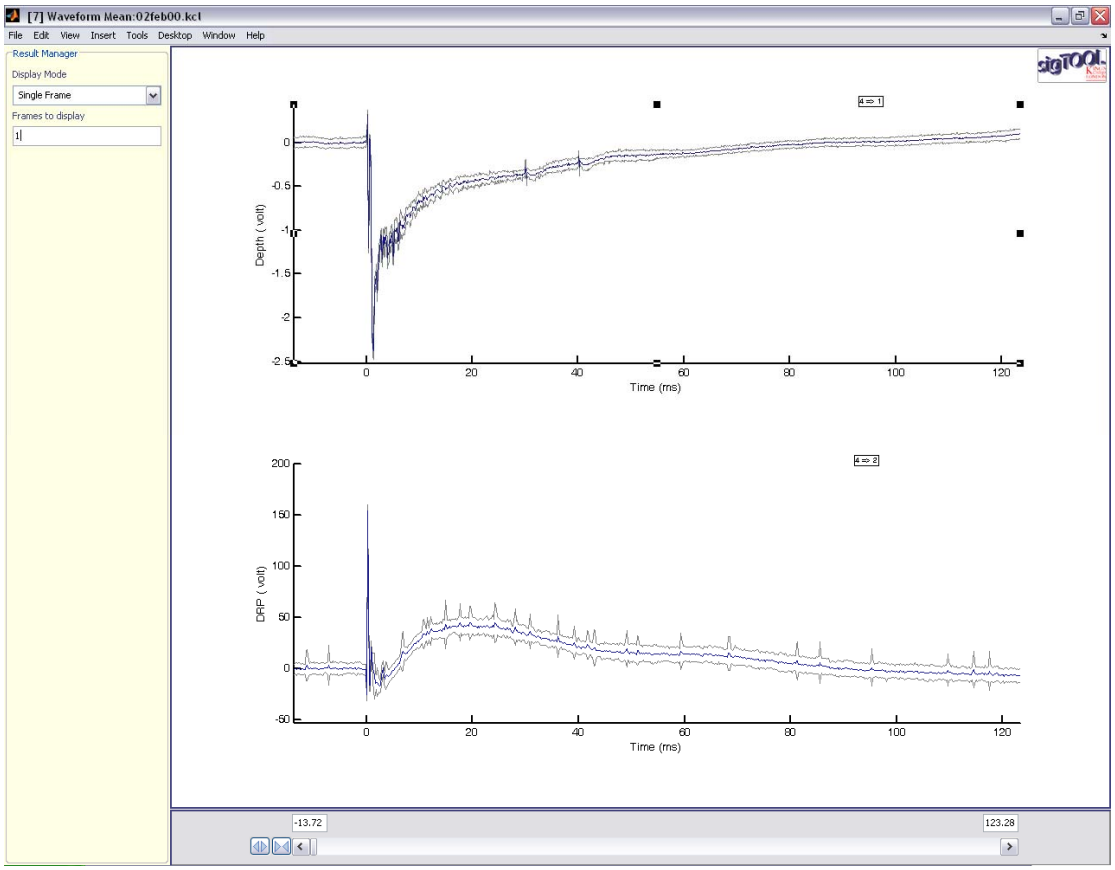


On the left of the screen is the Result Manager (this is evolving so you will see more options on screen than are shown in some of the figures this manual).

The Display Mode in the Result Manager controls the display of the data.



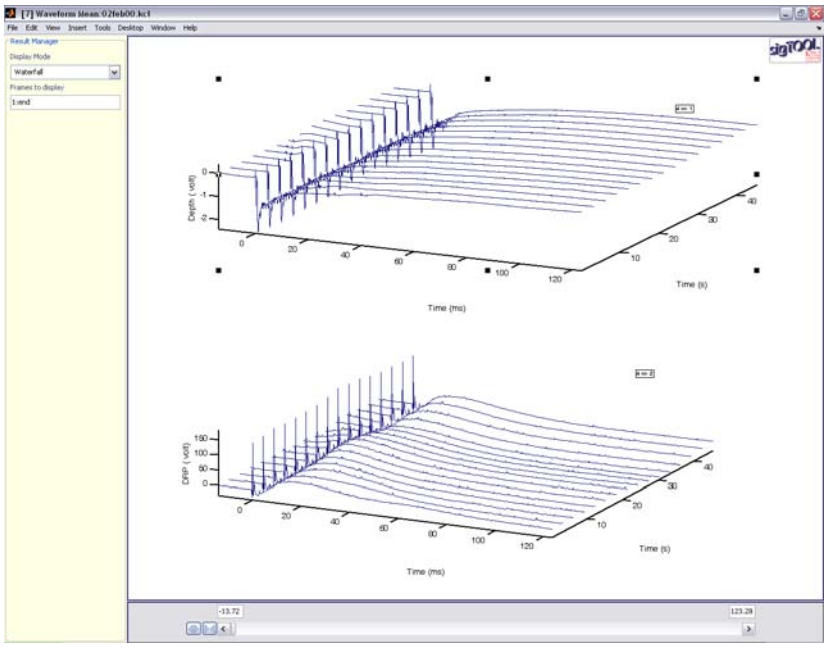
Click on the Display Mode and select Single Frame.



The multi-frame display is replaced with single frames. The means and standard deviations for the first frame in the analysis (Sweeps 1 through 20) is now displayed. Change the frame by editing the Frames to display setting in the Result Manager. Alternatively, click on the graphics panel and scroll through the frames using Page Up and Page Down.

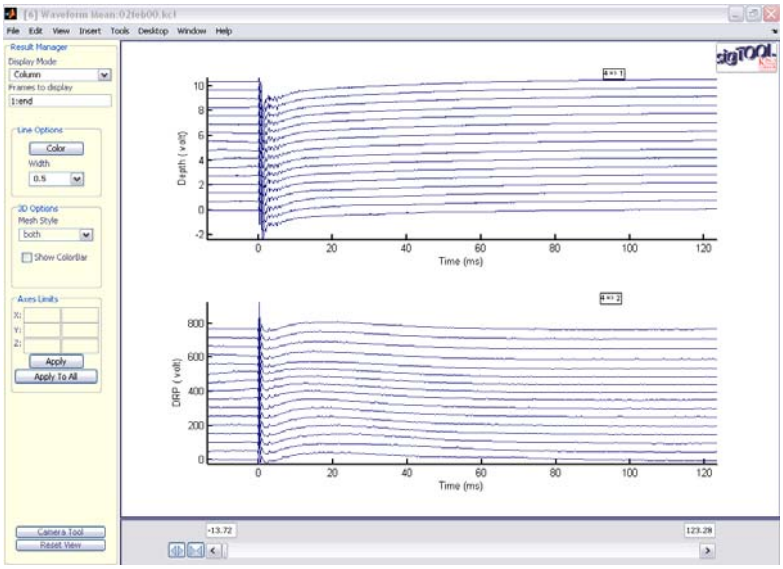
You can control the x-axis limits by using the controls at the bottom of the screen as in a sigTOOL data view (see above). For other methods of changing the axis limits, see “Changing the axes” below.

For these averages, and many other sigTOOL analysis results you can also select a 3D data representation. Select Waterfall from the Result Manager:

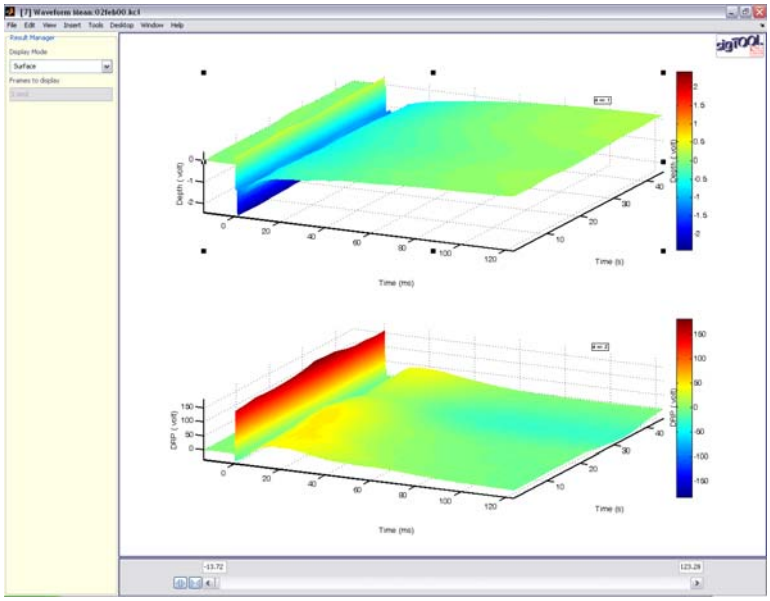


The sixteen separate averages are now shown in a 3D view with the timebase on the x-axis as before, but the amplitude now shown on the z-axis. The y-axis shows the time offset to the start of each average i.e. to frame 1, 21, 41 etc in the original data.

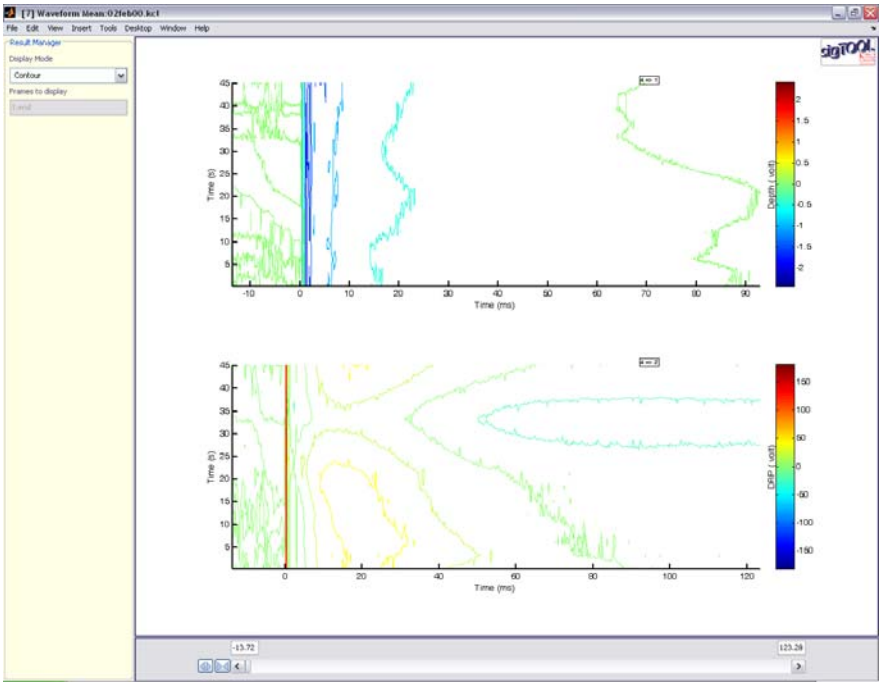
To display these traces as a simple column, select the ‘Column’ option from the Display Mode control in the Result Manager. Note that you can move individual lines on the y-axis in this display mode – just left click on a line with the mouse and move to the desired position with the mouse button down.



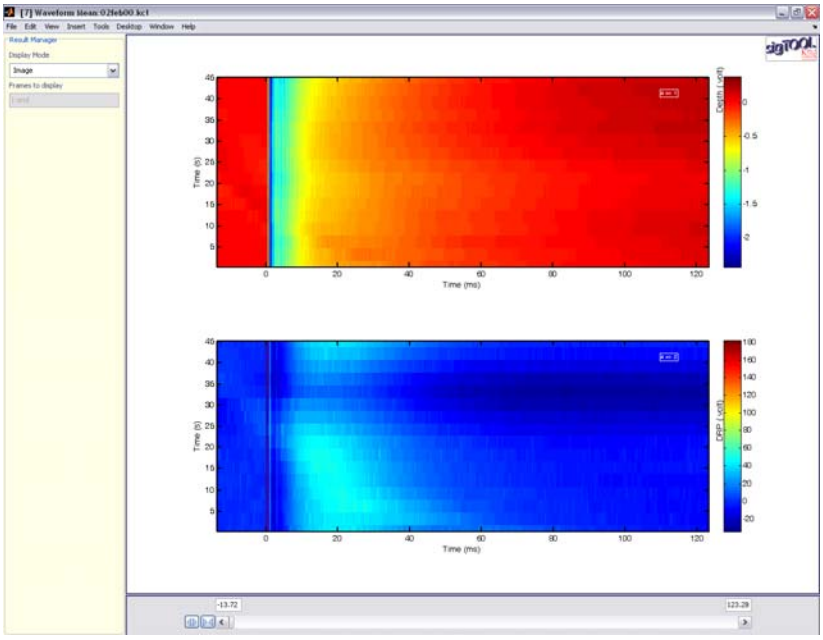
If you want a waterfall style display drawn as a surface with colour, choose Surface in the Result Manager Display Mode:



Right-click on the colour bars to change the colour settings. To view the surface from above as a contour map, choose Contour in the Result Manager Display Mode:



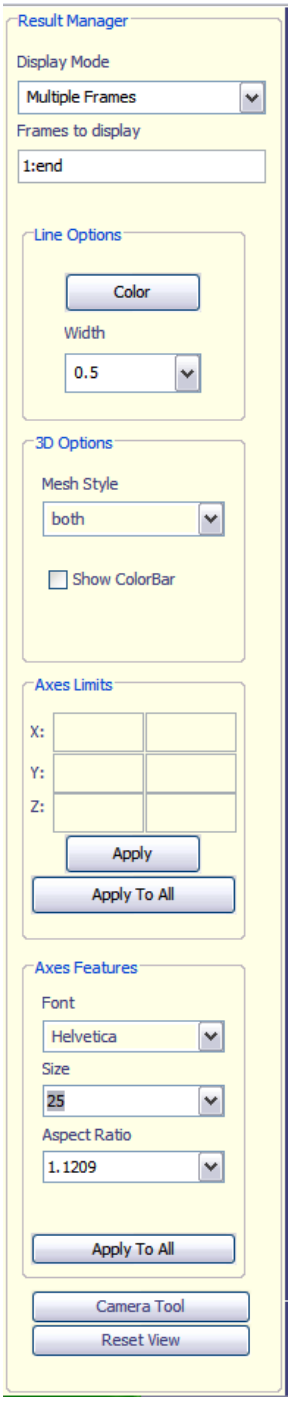
If you prefer to preserve a colour surface, choose Image in the Result Manager Display Mode (this produces better results with other analysis types e.g. spectrograms):



The remaining choice from the Result Manager is Scatter which will draw a scatter plot. In this case, that selection makes little sense and the result will vary according to the data – an error may or may not be thrown at the command line.

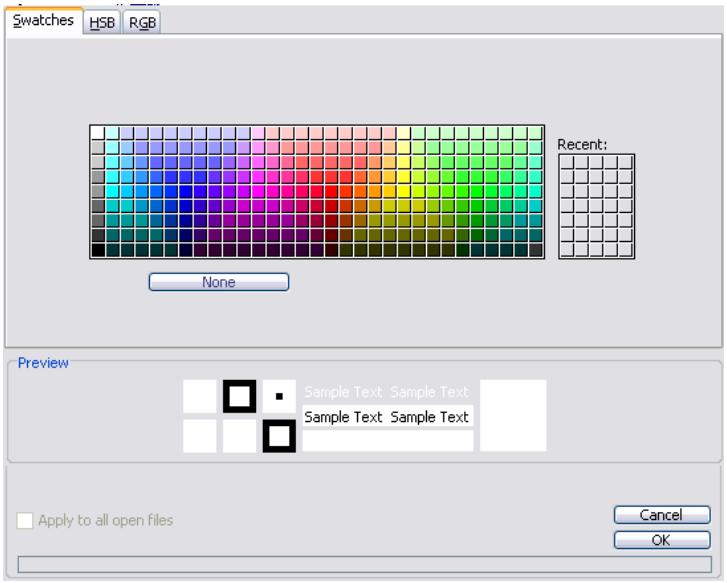
Formatting graphics the Result Manager

The Result Manager is still under development and the options you see may vary according to your MATLAB version and operating system.



The Result Manager provides a few options to alter the displayed graphics. For a full set of options, choose *Tools->Edit plot* from the main menu: that gives full access to the MATLAB plot editing features (select *Tools->Edit plot* again to restore the default sigTOOL mouse behaviour and context menus).

Line Options
Selecting *Color* will display a color chooser palette. The selected color will affect all data lines including those in line graphics, meshes on surface plots etc.



Width changes the widths of plotted lines including those in line graphs, surface meshes and contours. You may see little effect on-screen with small values of width as line widths are multiples of a screen pixel but the output to high resolution print devices will change.

3D Options
By default surface plots do not have a mesh added. To add a mesh, choose *Line Options -> Color* as above. To remove a mesh, choose *None* from the color chooser palette.
Mesh Style allows you to choose to plot a mesh parallel to the x-axis (row), y-axis (column) or both.
Show Colorbar toggles the colorbars on and off.

Camera Tool
You alter the position, rotation etc of any set of result axes using MATLAB's Camera Tool. Some of the options are useful only with a 3D graphic.

For further details see "camera toolbar" in the MATLAB help.
To activate the toolbar in sigTOOL, select the *Camera Tool* button. To remove the Camera Tool and restore the default sigTOOL mouse-

actions and menus click the button again (it should now be labeled *Close Camera Tool*).

Reset View

The Reset View button causes the view to be redrawn using the default settings (as defined in the analysis routine that created the graphic).

Opening and Saving results

The *File->Save* menu allows a sigTOOL result to be saved to a standard MATLAB data file (a .mat file). For improved backwards and forwards compatibility the result is saved as a structure. This is named 'sigTOOLResultStructure' in the file.

To open a result from a sigTOOL result view, select File->Open (the data will be presented in a new figure).

To restore a result from the command line, load the file then type:

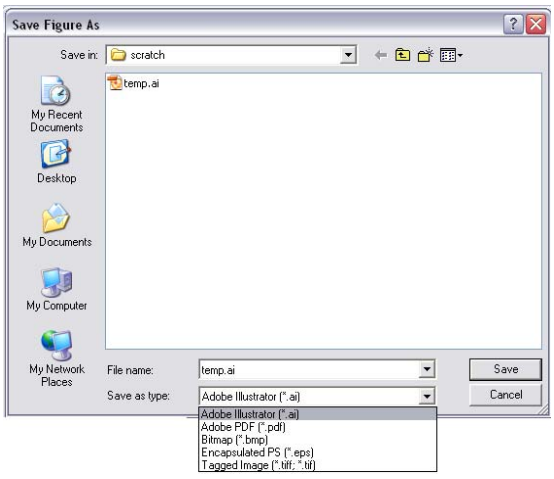
```
obj=sigTOOLResultData(sigTOOLResultStructure);
plot(obj);
```

Note that, for the present, result files will not be portable between operating systems and may not be portable between PCs using the same OS[3].

Exporting graphical results

You can export graphical results in several ways:

- Choose *File->Save As* from the result view, choose the format, select a file name and save the result. By default, sigTOOL saves these files in the …sigTOOL/scratch folder.

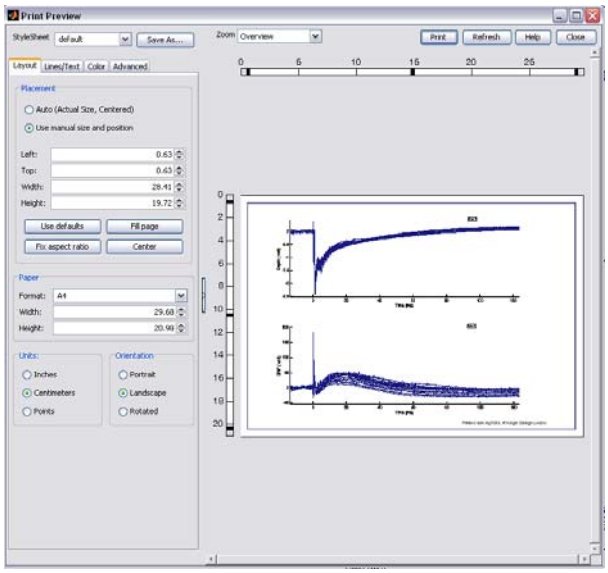


[3] This is because they may contain function handles with absolute paths. To improve portability between PCs, always install sigTOOL in the same folder e.g. c:\sigTOOL on Windows. This problem will be addressed in a future release of sigTOOL.

The generated file will be placed in the system temporary folder and, if possible, opened in a suitable viewer. On some platforms, you may need to close the document viewer for MATLAB to continue. To set up the viewers on Linux platforms, use the *File->Preferences* menu.

- Choose *File->Print* or *File->Print Preview*.

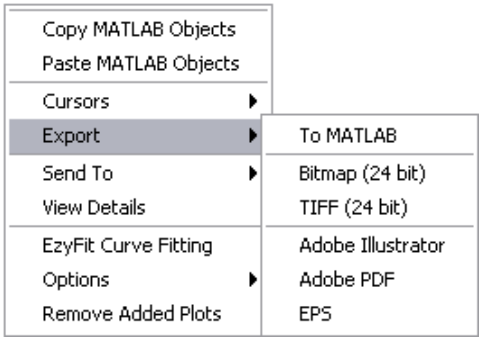
You can print to a printer or to a file (including to a PDF file via Abobe Acrobat, if installed).



If you select *Print Preview*, you will be able to adjust the print settings using the dialog above.

Note: If you have problems printing color 3D graphics, manually select the OpenGL renderer from the *Advanced* menu in the print preview.

- Alternatively, right-click on the result view and export the data from the drop-down menu:



The generated file will be placed in the system temporary folder and, if possible, opened in a suitable viewer. On some platforms, you may need

to close the document viewer for MATLAB to continue. To set up the viewers on Linux platforms, use the *File->Preferences* menu.

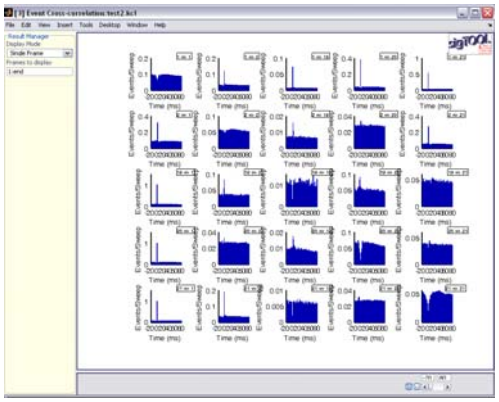
Cutting and pasting graphics objects in sigTOOL

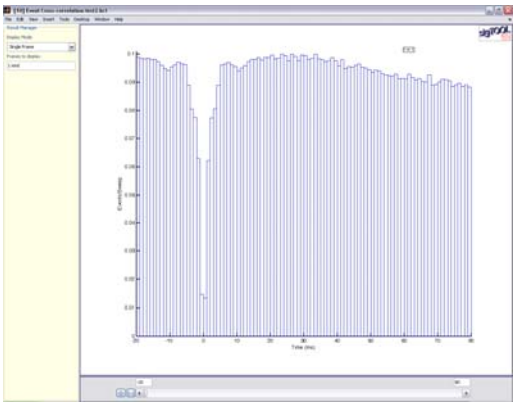
You can copy and paste MATLAB graphics objects between sigTOOL axes using the menu above. Note that unlike most copy-paste sequences, no graphics are copied when you first select Copy MATLAB Objects. Copying and pasting are done simultaneously when you select Paste MATLAB Objects. Therefore, any changes to those objects between the Copy and Paste commands will affect the pasted result.

Copying and pasting in this way preserves the original data scaling. If the source and target axes are very differently scaled you may not get a useful result. Text is positioned relative to the axes so it may not appear where you would like it in the target graph.

Selecting graphs

If you have a many results displayed in a single window, you may prefer to examine each one in a separate window. Just double-click on the graph of interest, in this case that at the top left, to open it in a new display:





Changing the axes

Several methods let you change the range of the axes in a sigTOOL result view. Note that, when these methods are used to alter the x-axis, the changes will be applied to all subplots in a result view.

Using the cursor

In a 2D result view you can click on an axis tick and drag it to a new position. To do this:

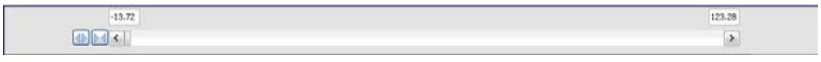
1. Click on the required set of axes to select them
2. Left-click the mouse close to a tick on the axis to alter and drag the mouse to the new position required. The cursor will change to a left/right or up/down drag format while you drag it.
   For the zero tick, the zero offset on the axis will be shifted. For a non-zero tick, the magnification will alter.

Alternatively, left click the mouse just outside of the plot area (and not on a tick or its label), then drag it over the required range. Note that the initial click must be outside the plotting area, otherwise sigTOOL will select data rather than change the axes (see below).

Using the Result Manager For both 2D and 3D results, the Axes Limits controls in the Result Manager allow you to type the required settings into the text boxes:

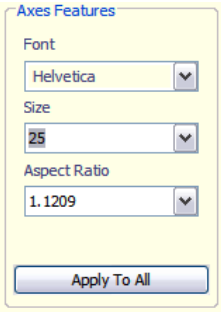
The displayed limits are those of the presently selected set of axes. Edit any box and press enter or click on the apply button to edit those axes. Leave the boxes blank to leave the relevant limit unchanged.
Click the Apply To All button to apply the settings to all axes in a result view.

For x-axis control, you can also you the panel at the base of each result view:



Axes Features

The Axes Features controls allow you to select the font, font size and aspect ratio of the displayed axes. This may be useful when exporting graphics to other software



Standard MATLAB controls

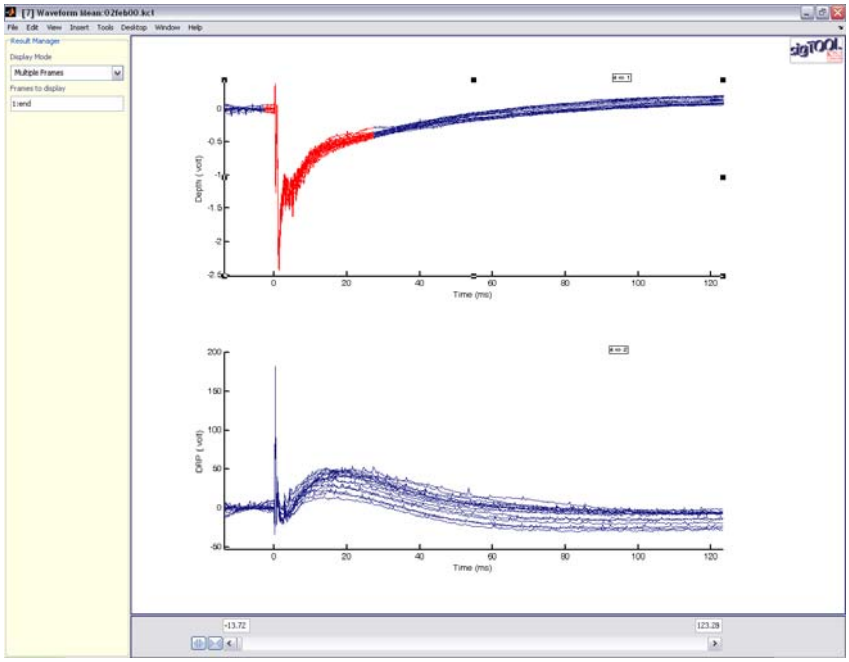
In addition, you can use the standard MATLAB controls. Either:

- Select Tools and either Pan, or Zoom In/Zoom Out.
- Select Tools->Edit Plot and use the MATLAB property editor. Note that the property editor does not update the controls that are internal to sigTOOL (pan and zoom do).

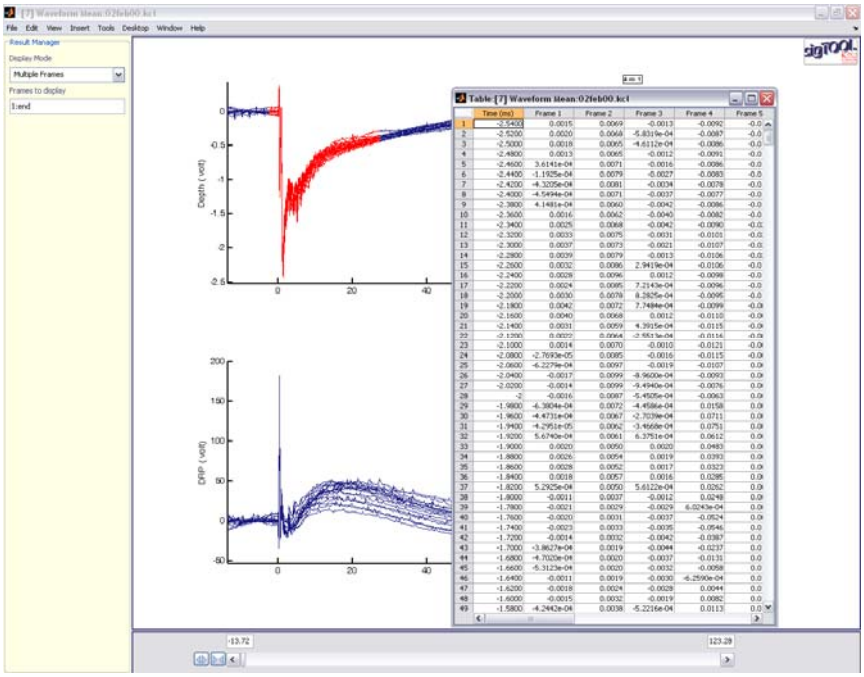
Exporting numerical results

- **Exporting selected data**

To select data in a sigTOOL result view left-click the mouse *within* the plot area of a set of axes and move it over the region of interest. Selected graphics will appear in red:

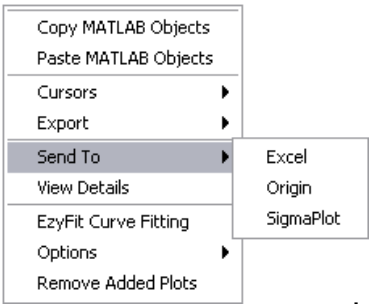


Double click on the selected graphics (or right-click and use the drop-down menu) to export the data in numerical format to a spreadsheet in MATLAB. These data can be cut-and-pasted into external software:



- **Exporting all data on Windows**

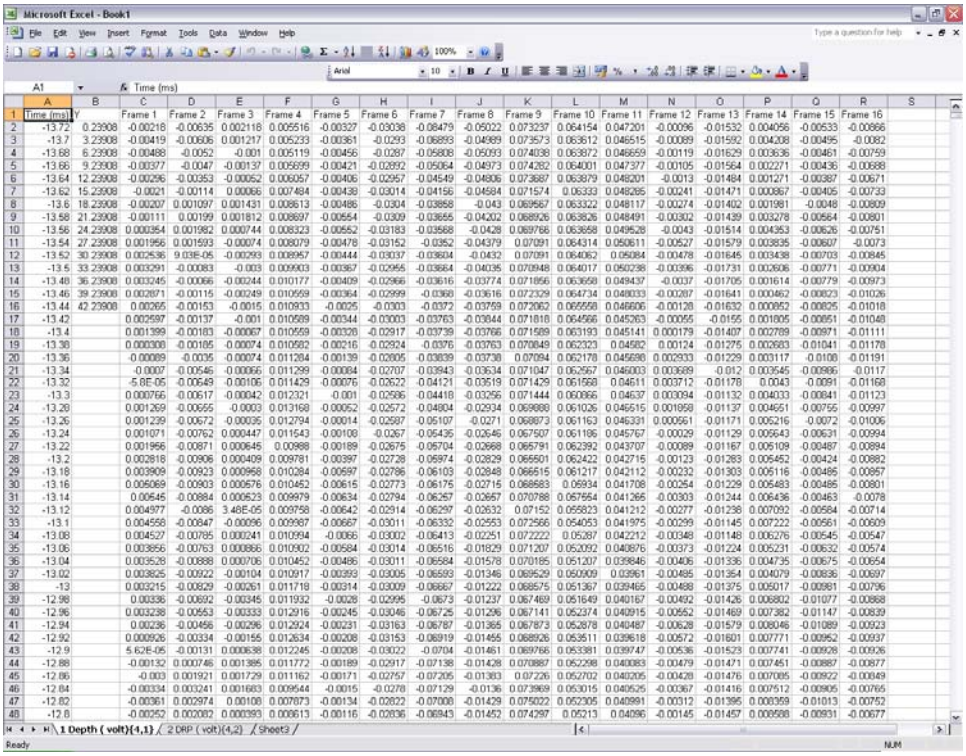
On Windows systems, you can export data from all axes or just from one by right-clicking on a blank area in the figure or on a blank area within the chosen set of axes respectively.



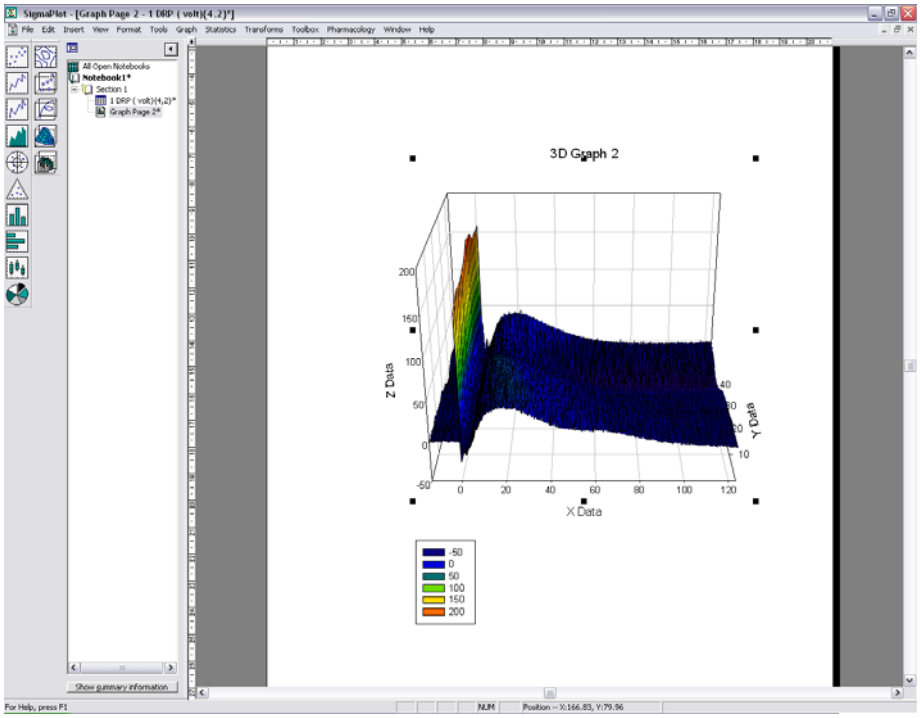
Data will be transferred to the target application using ActiveX. Supported formats are currently, Microsoft Excel, Systat SigmaPlot and OriginLab Origin software.

With multiple axes, data will be spread across several spreadsheets in the target file. With the averages shown above and Microsoft Excel for example, you will see the following result where the timebase and y-axis

offset are stored in the first two columns and subsequent columns contain the averages for each frame. The y-axis offsets in this case are the times of the first trigger used for each separate average (frame). The two graphs are represented in different worksheets.



Here is one of the averages shown as a surface plot in SigmaPlot:



- **Fitting curves using EzyFit**

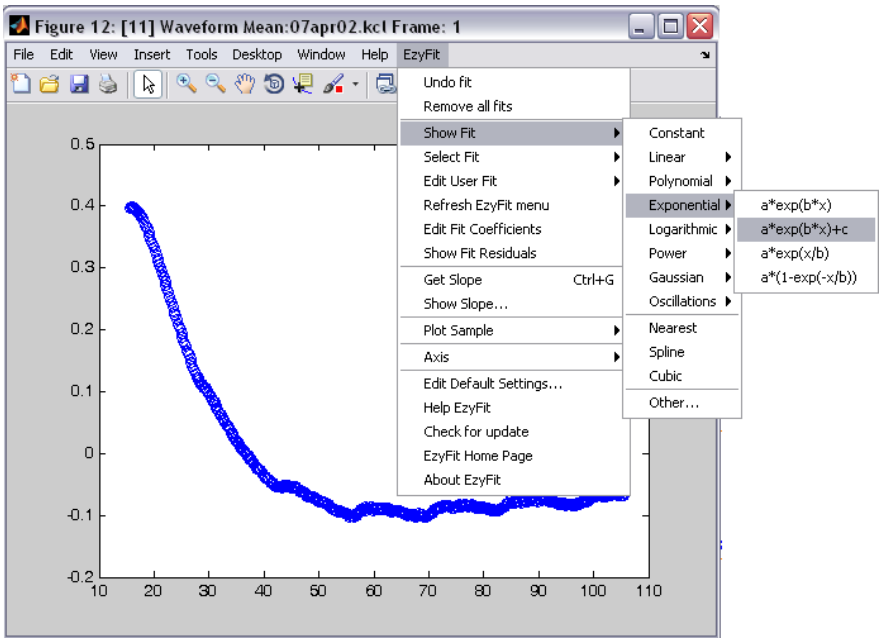
You can fit a curve to a result using EzyFit[4] written by Frederic Moisy which is available at:

http://www.mathworks.com/matlabcentral/fileexchange/loadFile.do?objectId=10176&objectType=file

To send all the data from a result view, right click on the selected graph. To send only selected data, select a region of data as above and right-click on it. Note that, for framed data, you may have only one line visible.

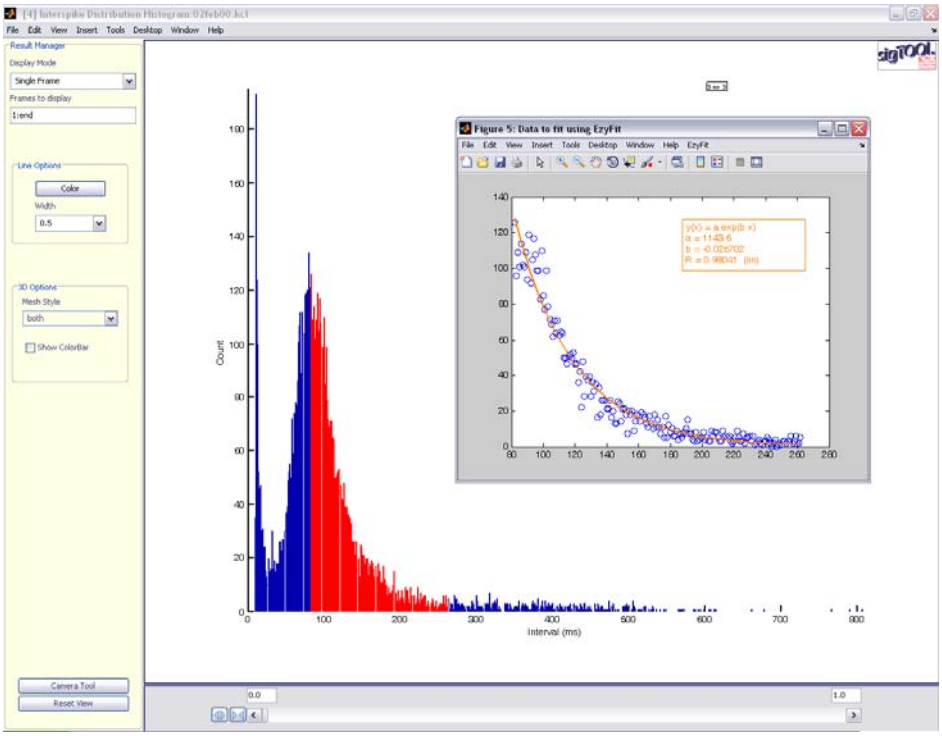
Choose 'EzyFit Curve Fitting' from the drop down menu.

Your data will be re-plotted in a new figure with the EzyFit menu added to it e.g.:



You can fit data to any 2D graphic from sigTOOL e..g to the falling edge of an interspike interval histogram as below. Here the falling edge is modeled as an exponential of the form $y(x)=a.e^{(b.x)}$ using EzyFit as shown in the inset Figure 5.

[4] EzyFit is not part of sigTOOL and needs to be downloaded separately. Install it following the author's instructions. Do not use "efmenu install" unless you want the EzyFit menu in all your MATLAB figures.



You can also select a subset of data for the fit from within EzyFit (choose ‘Select Fit’ instead of ‘Show Fit’ from the EzyFit menu.

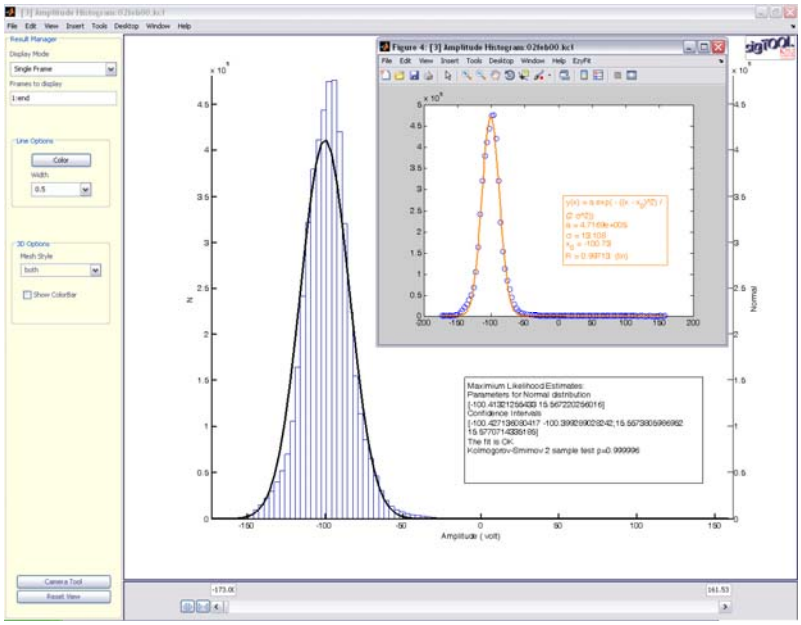
For further instructions, including details of how to add custom fits to the menu, see the EzyFit on-line help or visit:

http://www.fast.u-psud.fr/ezyfit/

- **Fitting distributions**

The Options context menu also provides for fitting statistical distributions to some results: those that return a probability density such as an interspike interval or waveform amplitude histogram.

Note these differ from the curves fitted by EzyFit as illustrated below.



To fit the distribution shown in bold in the sigTOOL result view, the maximum-likelihood estimates of the mean and standard deviation were found from the histogram. These values were used to generate a standard probability density function which was then scaled to the data. The two distributions were compared for equality using the Kolmogorov-Smirnov test.

The inset shows the Gaussian fitted to the same data using a least-squares algorithm in EzyFit.

As with curve fitting, you can fit a distribution to all the data or to a selected data region.