DARK HORSE NEURO

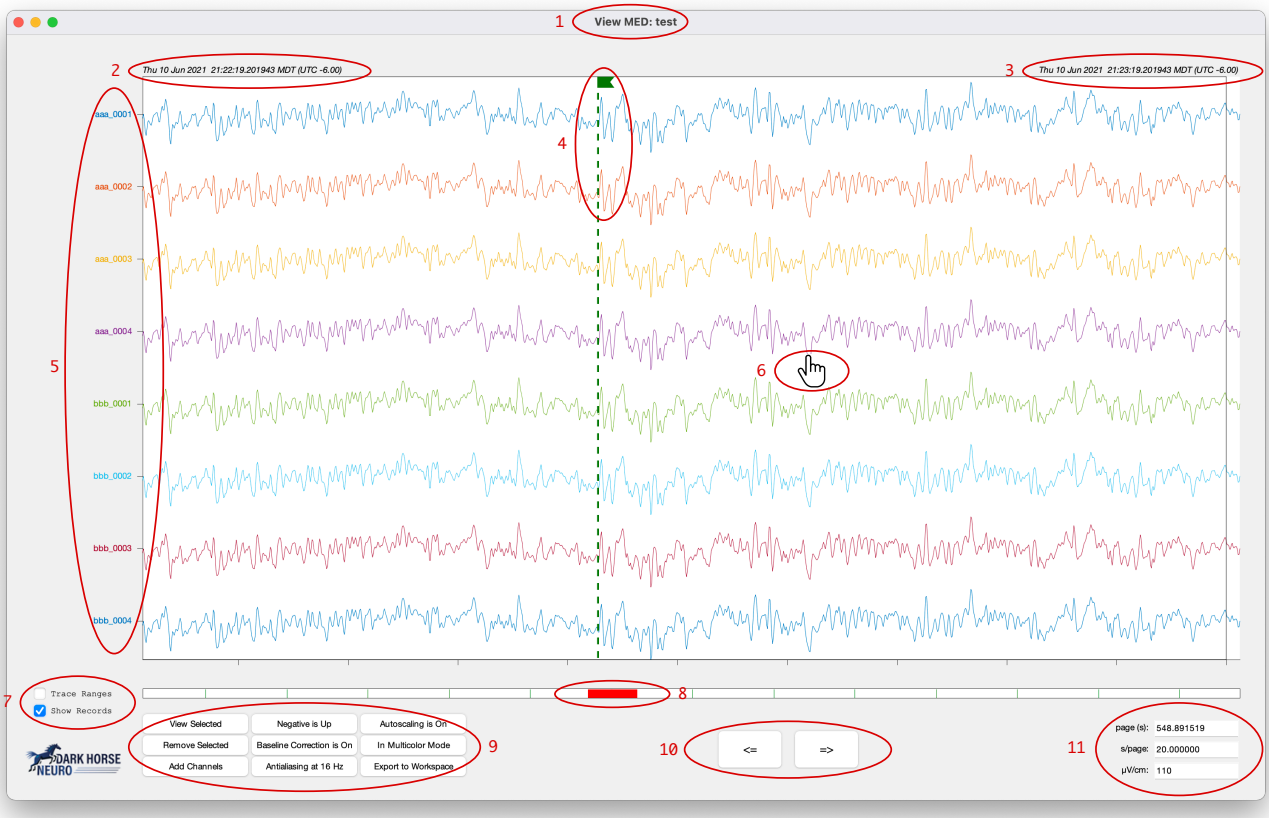
MED BASE

Matlab™ Software Suite

Instructions for Use

view_MED

Figure 1



Main Screen (figure 1):

1. Session name
2. Page start time
   a. Clicking on this rotates though:
      - True or offset calendar time of recording (depending on password access level)
      - True µUTC time (if password allows access)
      - Offset µUTC time (oUTC)
   b. Each click copies all available page start information to the system clipboard
3. Page end time
   a. Clicking on this rotates though:
      - True or offset calendar time of recording (depending on password access level)
      - True µUTC time (if password allows access)
      - Offset µUTC time (oUTC)
   b. Each click copies all available page end information to the system clipboard
4. MED Record
   a. Clicking on the flag shows the record time & contents
   b. Clicking on the flag copies the information to the clipboard
   c. A similar, gray hashed line is shown for discontinuities
5. Channel labels:

a. Channel Labels are selectable. Hold shift for multiple select.
b. The “Deselect All” button appears below the channel labels whenever channels are selected
c. The “View Selected” & “Remove Selected” buttons are enabled whenever any channels are selected.

6. Page Drag: Click and drag the screen to manually position the data.
7. Trace Ranges & Show Records checkboxes:
   a. The “Trace Ranges” checkbox shows the minimum & maximum for each pixel in a trace in light gray.
   b. The “Show Records” checkbox shows the session record as green lines in the session map, & any records that are present in the current window as green dashed lines with flag: clicking the flag shows more information about the record.
8. Session map:
   a. The full box (red plus white regions) represents the session extents
   b. The red portion of the box represents the current page within the session
   c. Clicking within session map will move the page start to the clicked point
   d. If the “Show Records” checkbox is checked, session records are displayed in the session map as green lines.
9. Control buttons:
   a. “View Selected”: If channels labels are selected, it removes unselected channels from the viewer
   b. “Remove Selected”: If channels labels are selected, it removes selected channels from the viewer
   c. “Add Channels”: Brings up a dialog to select channels to add to the viewer from the current session. Channels from different MED sessions cannot be added.
   d. “Negative is Up”: Amplitude orientation on the screen. If clicked the button title changes to “Negative is Down”. The button toggles between these two modes.
   e. “Baseline Correction is On”: The extents of each trace on the screen have a least absolute deviation fit subtracted from them to keep them straight and centered on their channel label. Clicked this button will change the button title to “Baseline Correction is Off”. The button toggles between these two modes.
   f. “Antialiasing at *x* Hz”: The traces are filtered to prevent screen aliasing. The lowpass cutoff is at set at four samples per cycle and depends on the screen pixel width, sampling frequency of each trace, and window time extents. If clicked, the button title changes to “Antialiasing is Off”. The button toggles between these two modes. If screen aliasing is not possible on any channel (e.g. small time window), the button will automatically switch to “Antialiasing is Off”.
   g. “Autoscaling is Off”: The amplitude scale of the channels can be selected automatically to fit 95% channel sample values within their channel label bands on the screen. If clicked, the button title changes to “Antialiasing is On” and this scaling is activated. The button toggles between these two modes.
   h. “In Multicolor Mode”: Traces are displayed in Matlab colors. If clicked the button title changes to “In Monochrome Mode” and the traces are all displayed in blue. The button toggles between these two modes.
   i. “Export to Workspace”: If clicked, a dialog appears asking for a variable name, and then exports the current page extents to the base Matlab workspace as a MED session structure of the specified name. The data in the contained in the exported structure are the values as stored, i.e. not decimated and filtered as for display.
10. Page Movement Buttons:
    a. The right facing arrow moves the page forward by the value in the “s/page” page parameter box.
    b. The left facing arrow moves the page backward by the value in the “s/page” page parameter box.

c. The keyboard left & right arrows perform the same function as clicking these buttons.
d. Clicking theses buttons while holding “Command” moves the page by one-third of the value in the “s/page” page parameter box.
e. Clicking theses buttons while holding “Option” moves the page by one-tenth of the value in the “s/page” page parameter box.
f. Up & down arrows default to changing trace amplitudes when the Page Movement Buttons are highlit.

11. Page Parameter Boxes:
    a. “Page (s)”: The page start, in seconds, relative to the session start. Values can be entered into this box to go to a specific time in a session. The box auto-updates with page movement. If this box is highlit, the up and down arrows can be used to change the value, and the “Option” & “Command” buttons can be used to modify the step size.
    b. “s/page”: The current page width in seconds. Values can be entered into this box to change the page width. If this box is highlit, the up and down arrows can be used to change the value, and the “Option” & “Command” buttons can be used to modify the step size.
    c. “µV/cm”: The amplitude of the traces. Values can be entered into this box to change the amplitude. If this box is highlit, the up and down arrows can be used to change the value, and the “Option” & “Command” buttons can be used to modify the step size.

Figure 2

MED Open Dialog (Figure 2):

1. Directory tree drop down menu
2. “..” parent directory. Window shows contents of current directory
3. Choose MED Session or set of MED channels

Behavior:

1. Multiple channels can be selected contiguously (with Shift) or discontiguously (with Command)
2. Only 1 session can be selected
3. Double-clicking opens a directory, not selects it

Matlab Command Window Usage:

1. view_MED <return>
   - Uses default password (specified in view_MED.m, line 9)
   - Launches MED Open Dialog for session or channel selection
   - Same as view_MED([], []) <return>
2. view_MED([], ‘password’) <return>
   - Uses passed password
   - Launches MED Open Dialog for session or channel selection
3. view_MED(session, []) <return>
   - Uses default password (specified in view_MED.m, line 9)
   - Opens the passed session, from its beginning
4. view_MED(session, ‘password’) <return>
   - Uses passed password
   - Opens the passed session, from its beginning

read_MED

read_MED() is a function that returns a MED session structure that can be used from the command line or within functions or scripts.

read_MED() requires 1 to 8 inputs.

Prototype:

```
session = read_MED(file_list, [start_time], [end_time], [start_index], [end_index],
[password], [indices_reference_channel], [samples_as_singles]);
```

read_MED() returns a single Matlab session structure.

Arguments in square brackets are optional => '[]' will substitute default values

Input Arguments:

file_list: string array, strings can contain regexp

start_time: if empty/absent, defaults to session/channel start (unless indices are specified)

end_time: if empty/absent, defaults to session/channel end (unless indices are specified)

start_index: if empty/absent, defaults to session/channel start (unless times are specified)

end_index: if empty/absent, defaults to session/channel end (unless times are specified)

password: if empty/absent, proceeds as if unencrypted (but, may error out)

indices_reference_channel: if empty/absent, and necessary, defaults to first channel in set

samples_as_singles: if empty/absent, defaults to 'false' (options: 'true', ‘false’)

> If samples_as_singles is set to 'true', sample values are returned as singles (32-bit floating point numbers), rather than doubles (64-bit floating point numbers, the Matlab default type). Singles have adequate precision to exactly represent integers up to 24-bits. Exercising this option doubles the amount of data that can be stored in memory by Matlab.

In MED, times are preferable to indices as they are independent of sampling frequencies

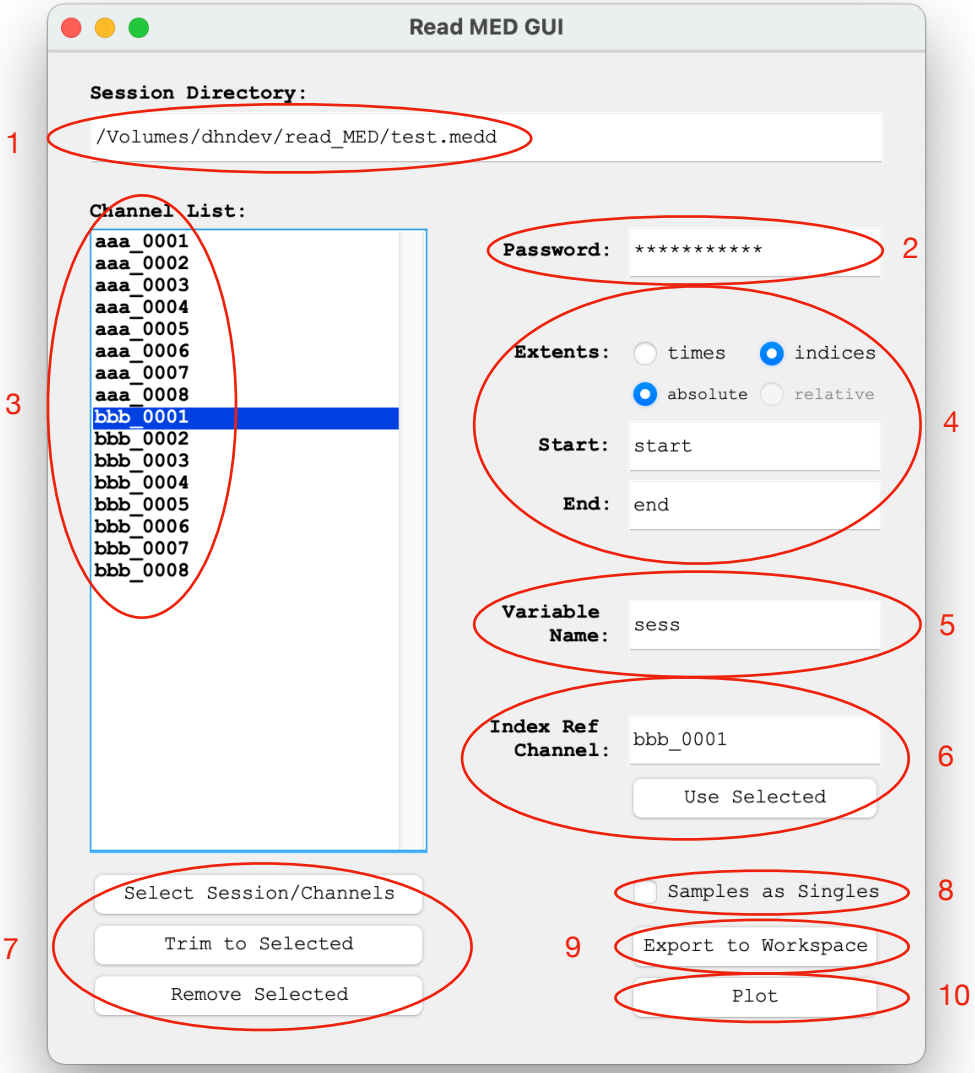
- times are natively in offset µUTC (oUTC), but unoffset times may be used
- negatives times are considered to be relative to the session start
- if indices are used, index numbering begins at 1, per Matlab convention

In sessions with varying sampling frequencies, the “indices reference channel” is used to determine the import extents on all channels when delimited indices

read_MED_GUI

read_MED_GUI() is read_MED() in the form of a GUI.

Figure 3



"read_MED_GUI <return>" from the Matlab command window launches the GUI depicted in figure 3. read_MED_GUI() is just a graphical version of read_MED() described above.

Figure 3:

1. The path to the parent directory of the current directory list (below). This field is editable.
2. Password to be used to read the session.
3. Current directory list. This field is multi-selectable with Shift & Command modifier keys.
4. Start and End point of the portion of the session to be read:
   - 'start' and 'end' keywords can be used
   - Contents can be times or indices (specified with radio button (6))
   - If contents are times:
     a) Positive values represent absolute μUTC times (offset or unoffset => software will differentiate).
     b) Values <= 0 represent μs from session start. For example:
        - start == 0, end == -10,000,000 retrieves the first 10 seconds of the file
        - start == -10,000,000, end == -20,000,000 retrieves the next 10 seconds
        - Etcetera
5. Matlab workspace variable name.
6. Base name of Indices Reference Channel (if required), and button that to use selected channel from the "Channel List".
7. Button to choose channels (or session):
   - If channels are selected within the Channel Lst "Trim to Selected" will remove all other channels.
   - If channels are selected within the Channel Llist "Remove Selected" will remove those channels.
8. Export sample vales as single precision numbers (4 byte floating point number which can precisely describe all integers up to 24-bits). This option its the memory requirement for the samples in half, as Matlab defaults to encoding all numbers as 8 byte floating point numbers ("doubles").
9. Button to export the data to the Matlab workspace named as the value in "Variable Name" field (5).
10. Calls plot_MED() (described below) to visualize the specified data. It does not export to the Matlab workspace.

Read_MED_GUI displays the equivalent commands in the command windows as text. This is to facilitate bypassing the GUI for integration into other programs:

```
file_list = {'/Volumes/dhndev/read_MED/test_subset.medd/
aaa_0001.ticd', '/Volumes/dhndev/read_MED/test_subset.medd/
aaa_0002.ticd'};

page_1 = read_MED(<file_list>, 'start', -100000, [], [], '<password>',
[], false);
```

matrix_MED

matrix_MED() is a function that returns a MED data in a **square matrix** of channel by sample dimensions. Data from channels are up or downsampled across the time specified, to the number of samples specified.

matrix_MED() requires 4 to 8 inputs:

Prototype:

```
matrix_struct = matrix_MED(chan_list, start_time, end_time, n_out_samps, [password], [antialias], [detrend], [trace_ranges]);
```

matrix_MED() returns a single Matlab matrix structure.

Arguments in square brackets are optional => '[]' will substitute default values

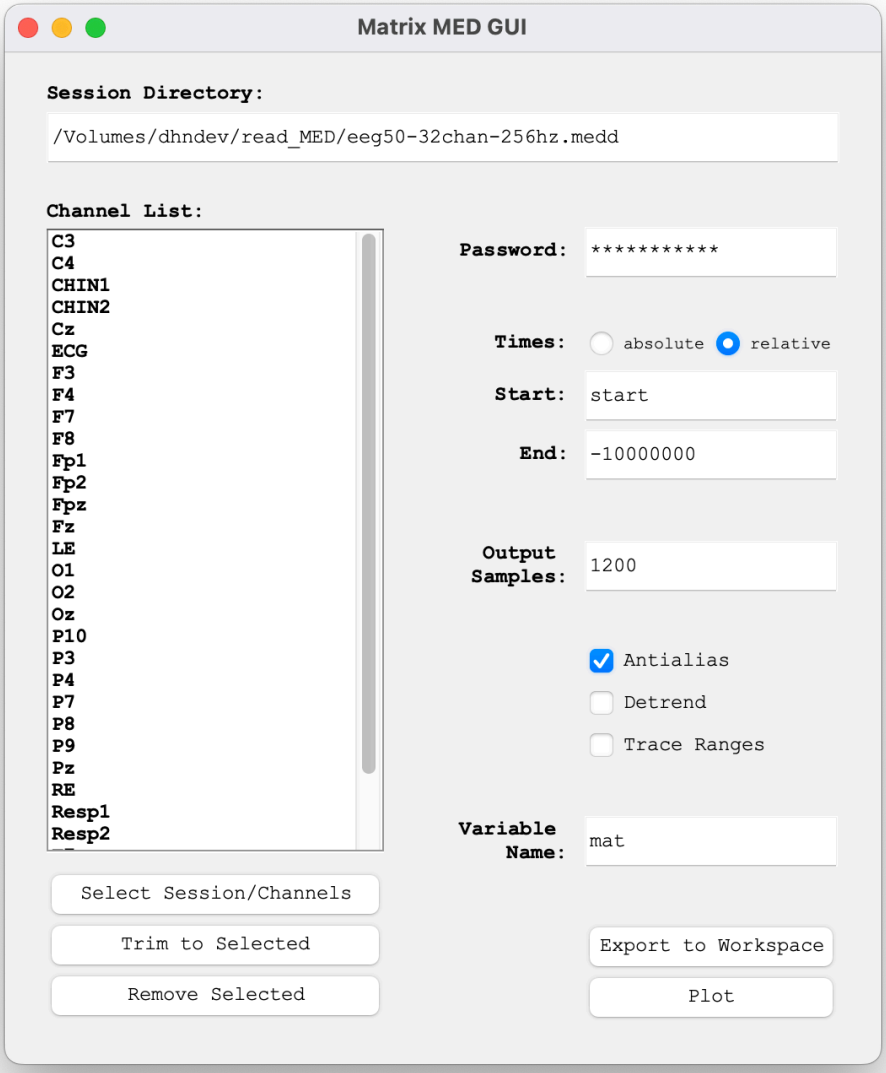
Input Arguments:

chan_list: cell array of strings (strings can contain regexp)
start_time: if empty/absent, defaults to session/channel start (unless indices are specified)
end_time: if empty/absent, defaults to session/channel end (unless indices are specified)
n_out_samps: the output matrix sample dimension
password: if empty/absent, proceeds as if unencrypted (but, may error out)
antialias: if empty/absent, defaults to 'true' (options: 'true', 'false')
detrend: if empty/absent, defaults to 'false' (options: 'true', 'false')
trace_ranges: if empty/absent, defaults to 'false' (options: 'true', 'false')

matrix_MED_GUI

matrix_MED_GUI() is matrix_MED() in the form of a GUI. As with read_MED_GUI(), the matrix_MED_GUI displays the commands required to make the same call to matrix_MED() without the GUI.

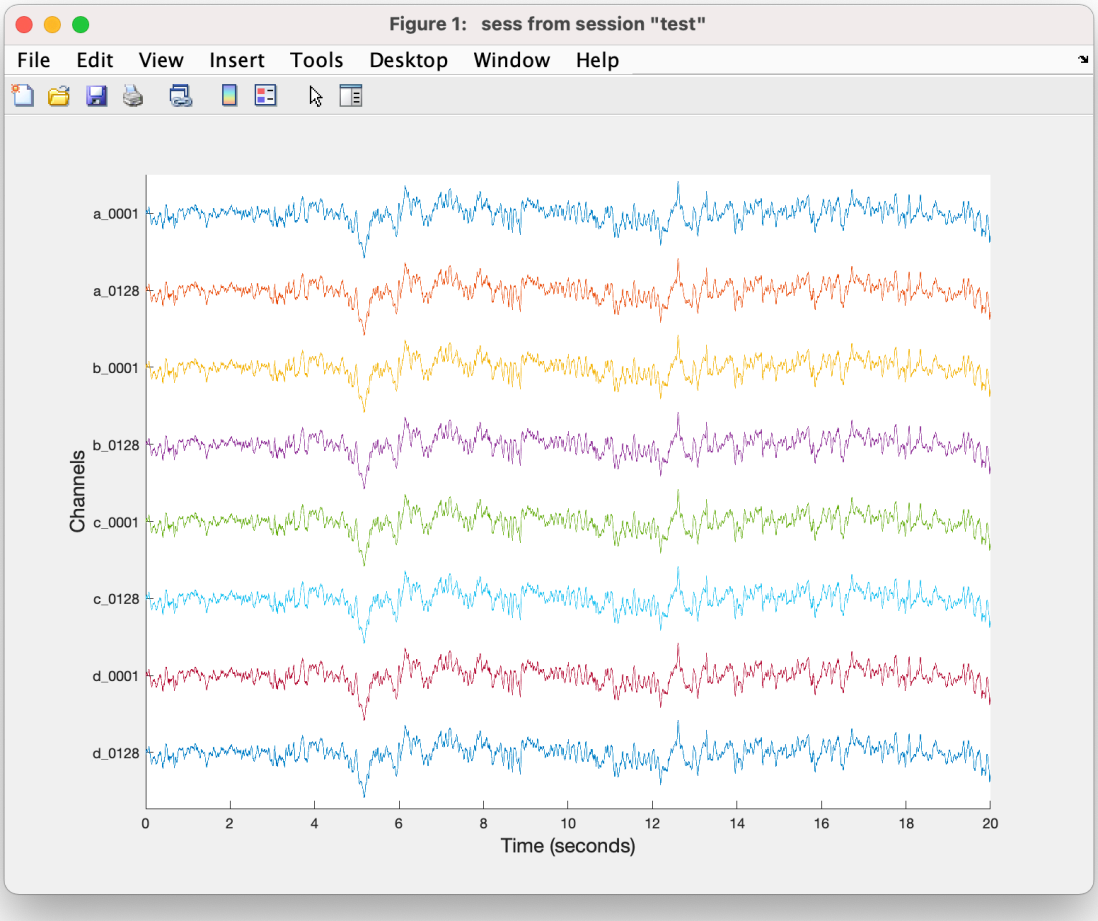
Figure 4



plot_MED

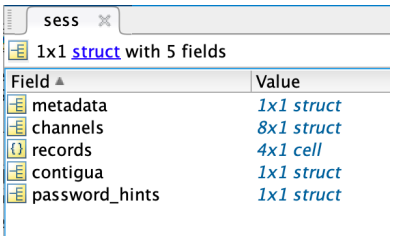
“plot_MED(session) <return>” from the Matlab command window plots the data in the passed MED session structure using standard Matlab plotting routines. Typical output is shown in figure 5.

Figure 5



MED Session Structure

MED Session Structure:



Contents:

1. Session Metadata (single structure)
2. Channels (structure array)
3. Records (cell array)
4. Contigua (structure array)
5. Password Hints (single structure)

MED Metadata Structure:

sess | sess.metadata

sess.metadata

Field	Value
path	'/Users/matt/Library/Mobile Documents/com~apple~CloudDocs/MED/read_MED/Datasets/test.medd'
start_time	65076008134
end_time	65096008193
start_time_string	'Wed 17 Mar 2021 19:04:36.008134 MDT (UTC -6.00)'
end_time_string	'Wed 17 Mar 2021 19:04:56.008193 MDT (UTC -6.00)'
session_start_time	65076008134
session_end_time	65240319617
session_start_time_string	'Wed 17 Mar 2021 19:04:36.008134 MDT (UTC -6.00)'
session_end_time_string	'Wed 17 Mar 2021 19:07:20.319617 MDT (UTC -6.00)'
absolute_start_sample_number	-1
absolute_end_sample_number	-1
session_name	'test'
channel_name	''
anonymized_subject_ID	''
session_UID	9139231079027973773
channel_UID	0
session_description	'test session description'
channel_description	''
equipment_description	'Neuralynx Atlas / Pegasus acquisition system'
acquisition_channel_number	-1
reference_description	'test reference description'
sampling_frequency	-1
low_frequency_filter_setting	0
high_frequency_filter_setting	-1
notch_filter_frequency_setting	-1
AC_line_frequency	60
amplitude_units_conversion_factor	1
amplitude_units_description	'microvolts'
time_base_units_conversion_factor	1
time_base_units_description	'microseconds'
recording_time_offset	1615964400000000
standard_UTC_offset	-25200
standard_timezone_string	'Mountain Standard Time'
standard_timezone_acronym	'MST'
daylight_timezone_string	'Mountain Daylight Time'
daylight_timezone_acronym	'MDT'
daylight_time_start_code	4323457849888997377
daylight_time_end_code	-4323453400302681857
subject_name_1	''
subject_name_2	''
subject_name_3	''
subject_ID	''
recording_country	'United States'
recording_territory	'Montana'
recording_city	'Bozeman'
recording_institution	'Neuralynx, Inc'

Contents:

- "no entry" values:
  - -1 for numeric values
  - '' for string values
- In Session structure, contains information relating to all channels, or "no entry" value when the value varies across channels
- In Channel structures, contains information relating to the specific channel.
- If the password used to read the file does not provide access to a particular field, the field will contain the string 'no access'.

MED Record Structure:

sess | sess.records | sess.records{1, 1}

sess.records{1, 1}

Field	Value
start_time	65166610786
type_string	'NlxP'
type_code	1350069326
version	'1.000'
subport	1
value	1

Fixed Contents:
1. Start time (oUTC or µUTC, depending on access)
2. Type string
3. Type code
4. Record version

Variable Contents:
1. Depends on record type
2. In example the variable contents are:
   - Subport number
   - Port value

MED Contiguon Structure:

sess | sess.contigua

sess.contigua

Field	Value
start_index	-1
end_index	-1
start_time	65076008134
end_time	65096008193

Description: A contiguon (plural "contigua") is a structure that contains extent information for regions of data between discontinuities. There will be at least on contiguon for every session.

Contents:
1. Start index: this may contain "no entry" values in session contigua, if the sampling frequency varies across channels
2. End index: this may contain "no entry" values in session contigua, if the sampling frequency varies across channels
3. Start Time: this will always be present
4. End Time: this will always be present

MED Password Hints Structure:

sess | sess.password_hints

sess.password_hints

Field	Value
level_1	'the level 1 password is 'test_L1_pw''
level_2	'the level 2 password is 'test_L2_pw''

Contents:
1. Level 1 password hint
2. Level 2 password hint

MED Channel Structure:

sess | sess.channels

sess.channels

Fields	metadata	data	records	contigua
1	*1x1 struct*	*160002x1 double*	[]	*1x1 struct*
2	*1x1 struct*	*160002x1 double*	[]	*1x1 struct*
3	*1x1 struct*	*320003x1 double*	[]	*1x1 struct*
4	*1x1 struct*	*320003x1 double*	[]	*1x1 struct*
5	*1x1 struct*	*640005x1 double*	[]	*1x1 struct*
6	*1x1 struct*	*640005x1 double*	[]	*1x1 struct*
7	*1x1 struct*	*800006x1 double*	[]	*1x1 struct*
8	*1x1 struct*	*800006x1 double*	[]	*1x1 struct*
9				

Contents:
1. Channel Metadata (single structure)
2. Data (time series data array)
3. Records (cell array)
4. Contigua (structure array)