EEG in special situations (acute settings and the ICU)

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Associate Chief Medical Officer (Critical Care)

Rush Medical College

tbleck@gmail.com

RUSH UNIVERSITY MEDICAL CENTER

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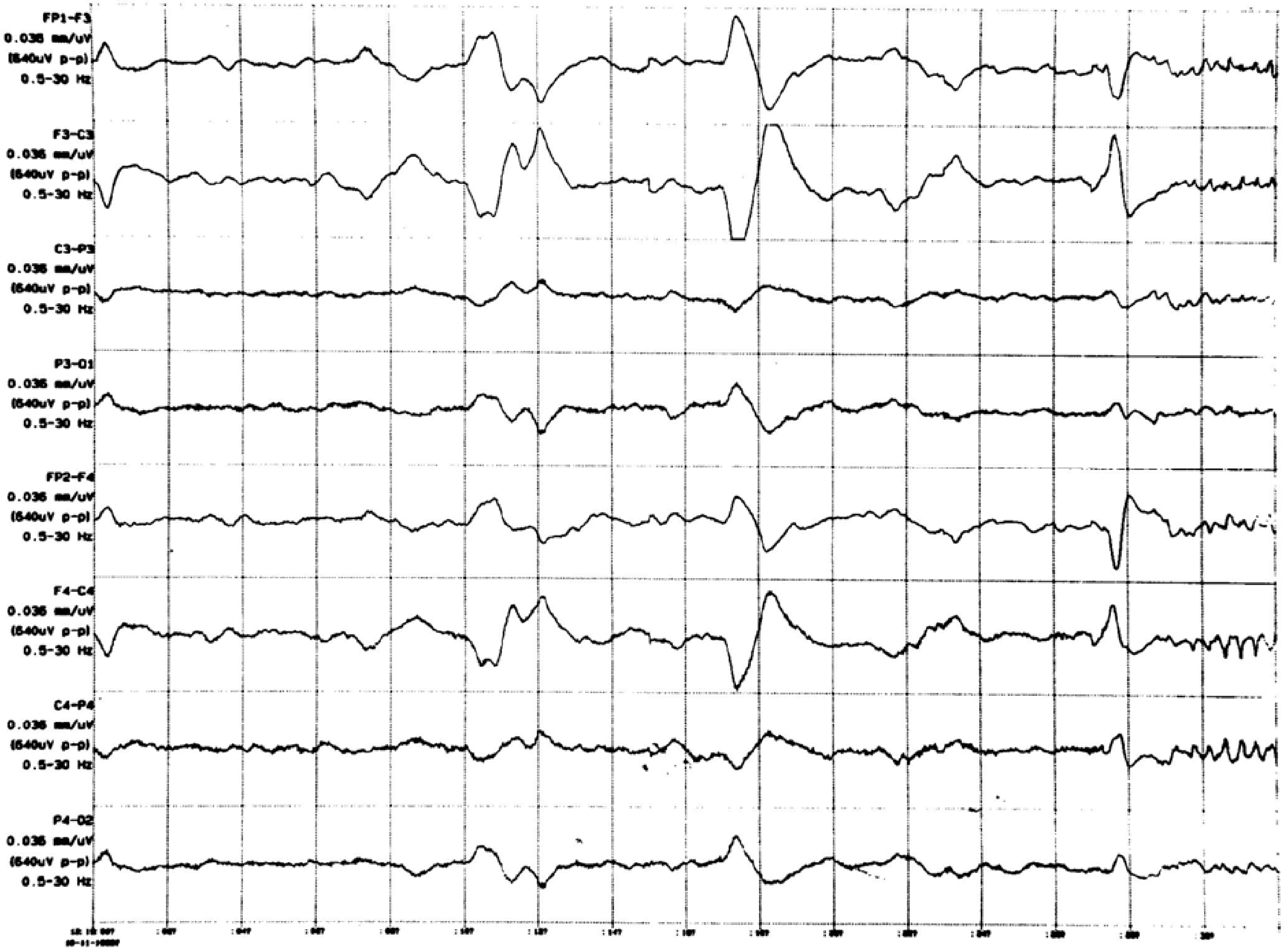
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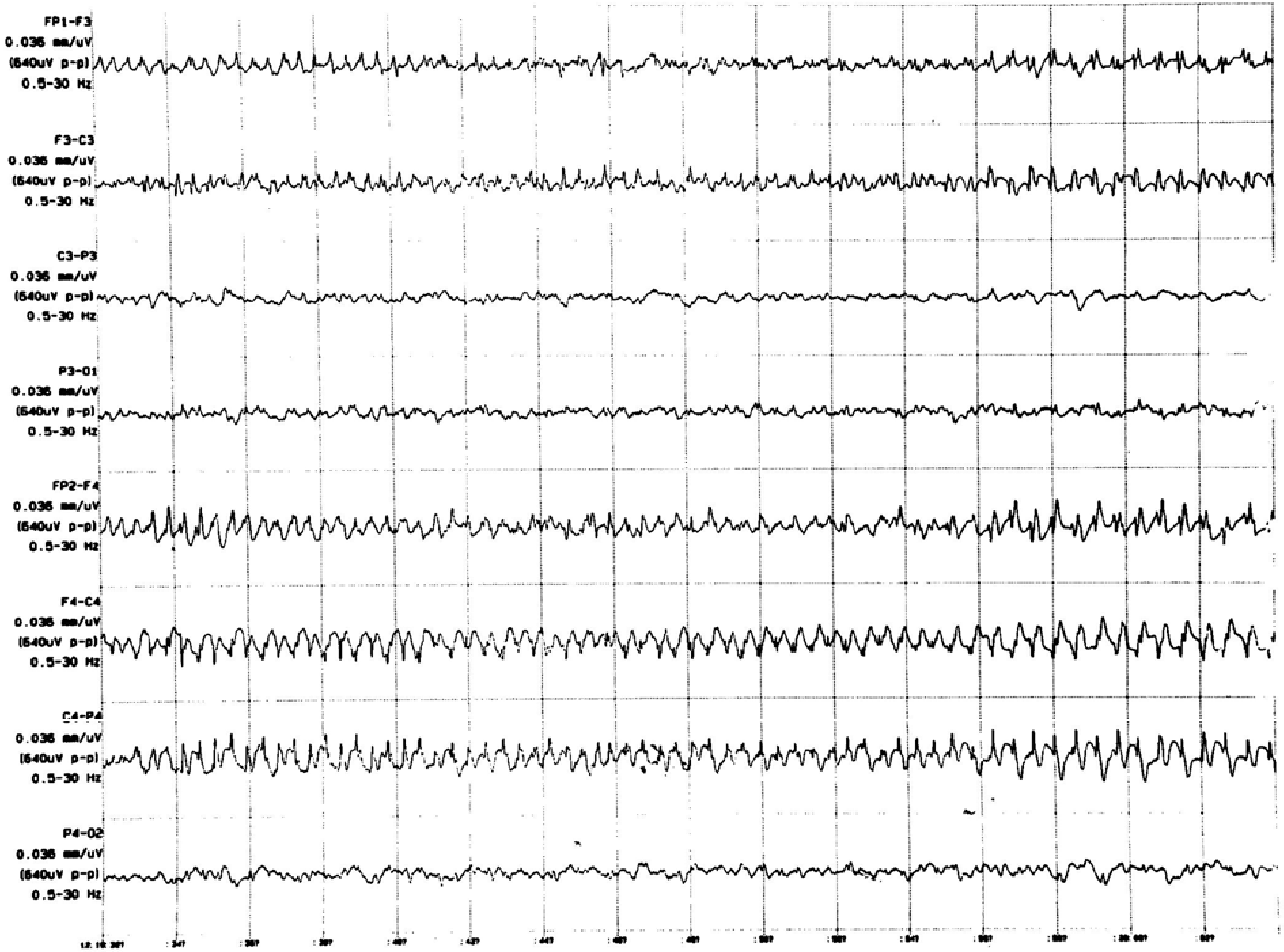
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
F3-C3
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
C3-P3
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
P3-O1
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
FP2-F4
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
F4-C4
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
C4-P4
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
P4-O2
0.036 mm/uV
(640uV p-p)
0.5-30 Hz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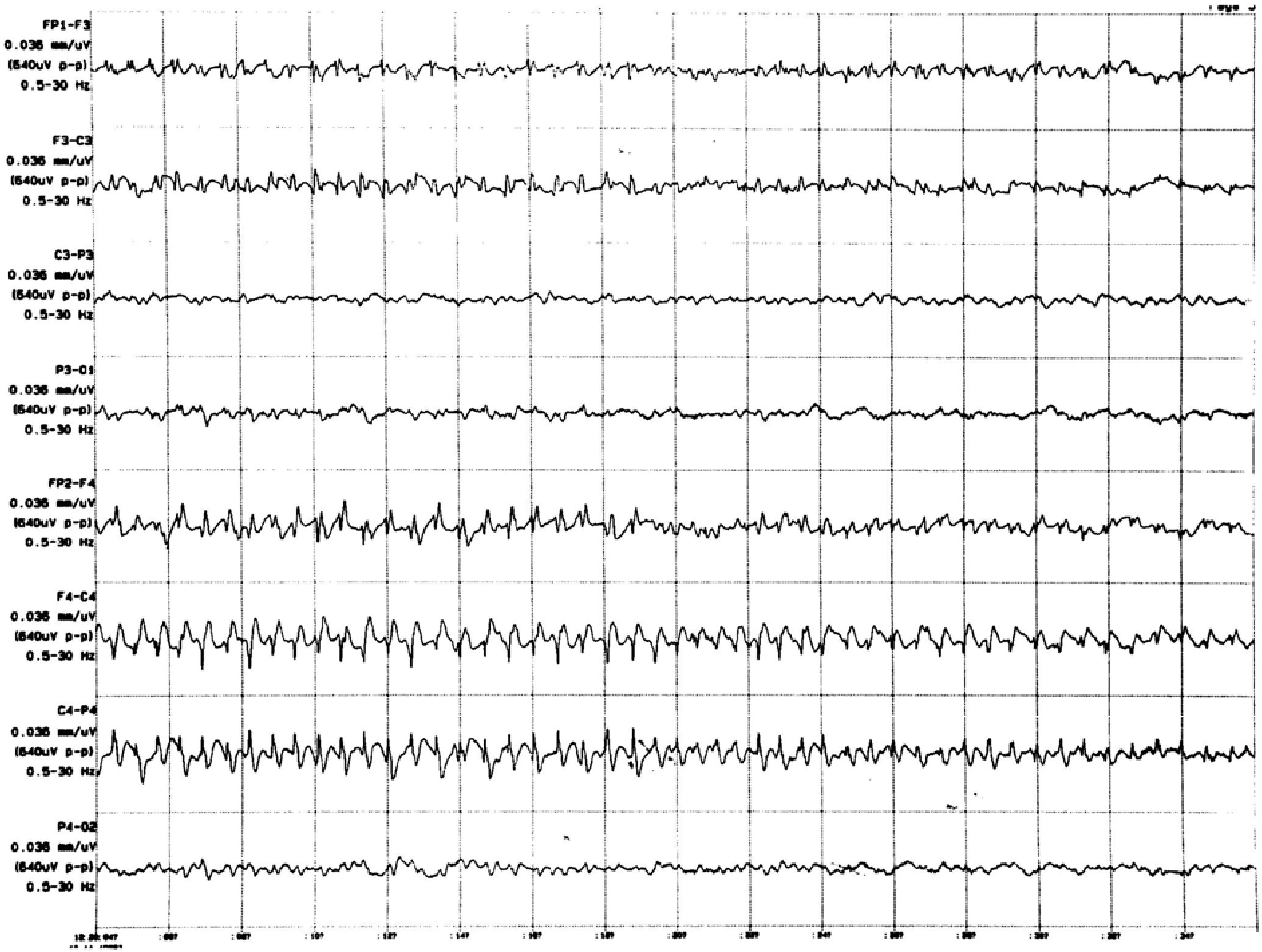
(640uV p-p)
0.5-30 Hz
F3-C3
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
C3-P3
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
P3-O1
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
FP2-F4
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
F4-C4
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
C4-P4
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
P4-O2
0.036 mm/uV
(640uV p-p)
0.5-30 Hz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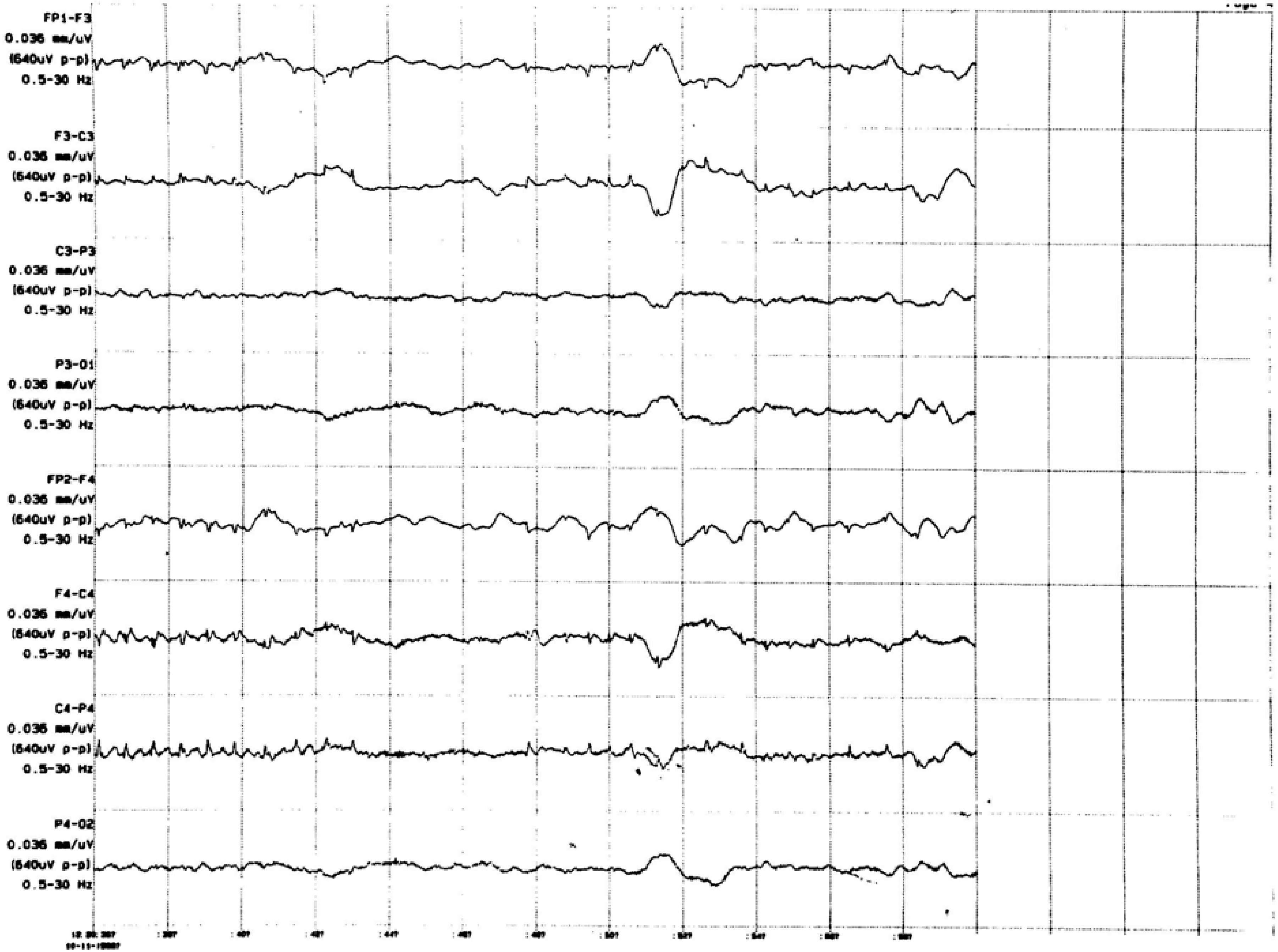
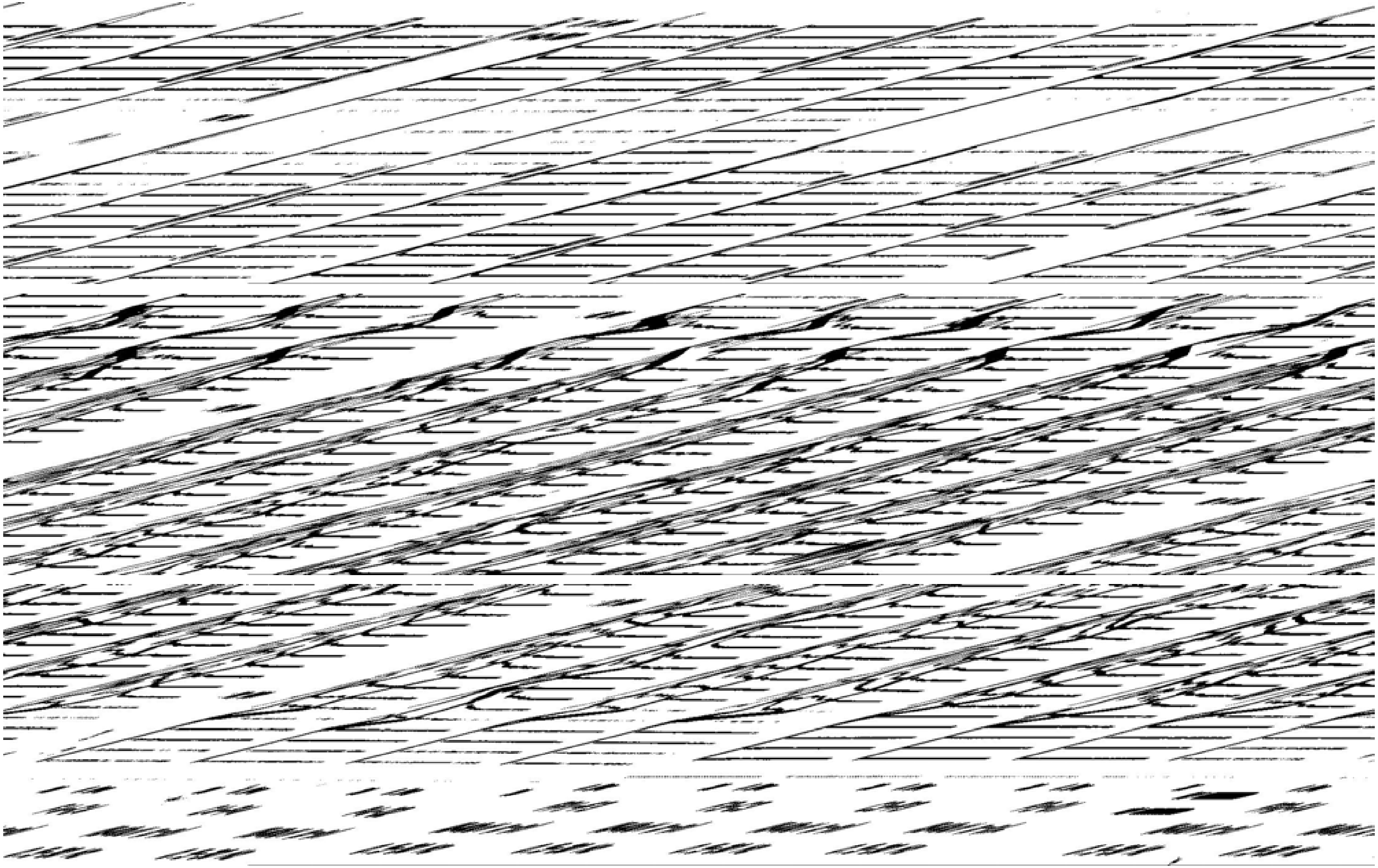
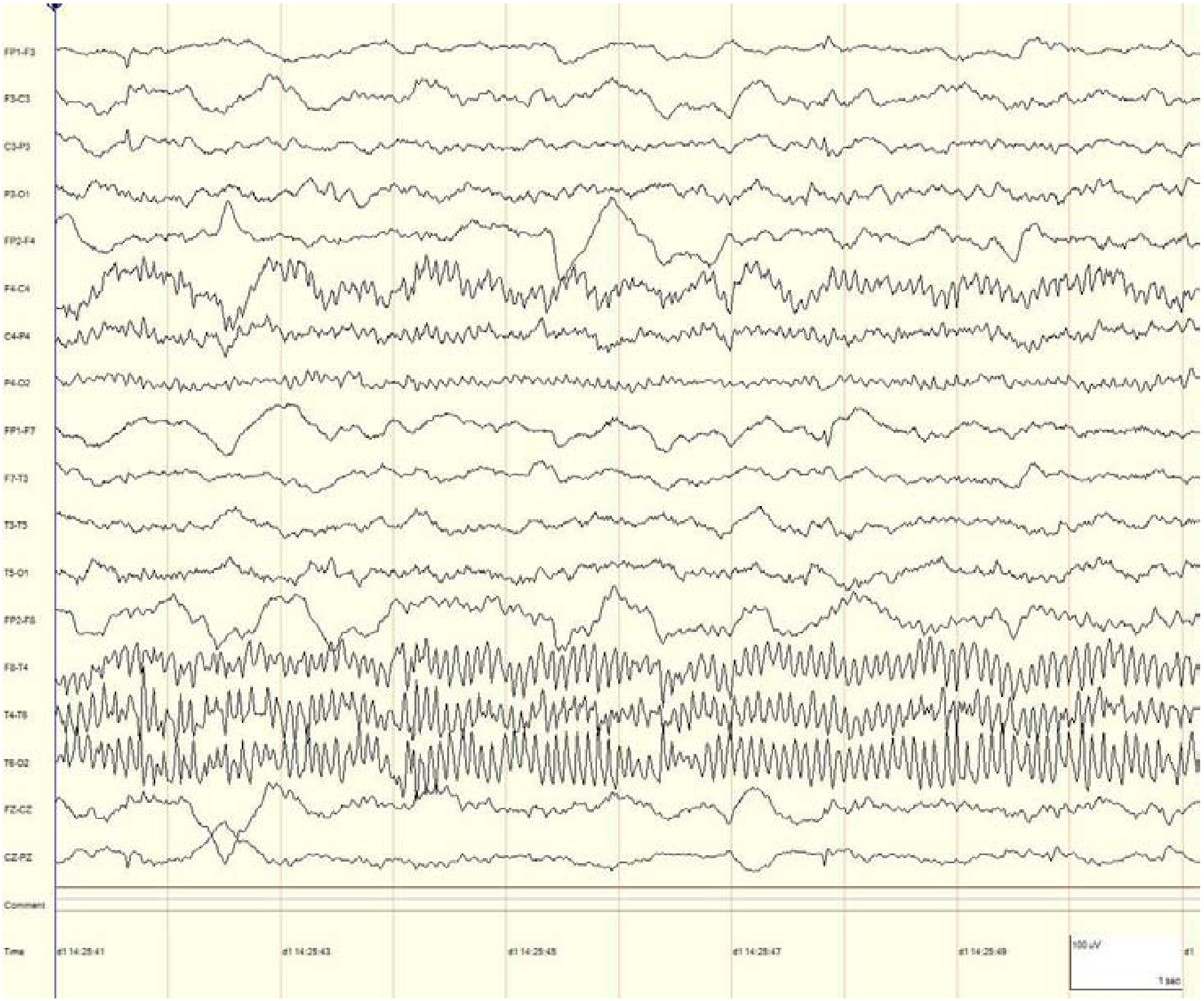
0.5-30 Hz
F3-C3
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
C3-P3
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
P3-O1
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
FP2-F4
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
F4-C4
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
C4-P4
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
P4-O2
0.036 mm/uV
(640uV p-p)
0.5-30 Hz

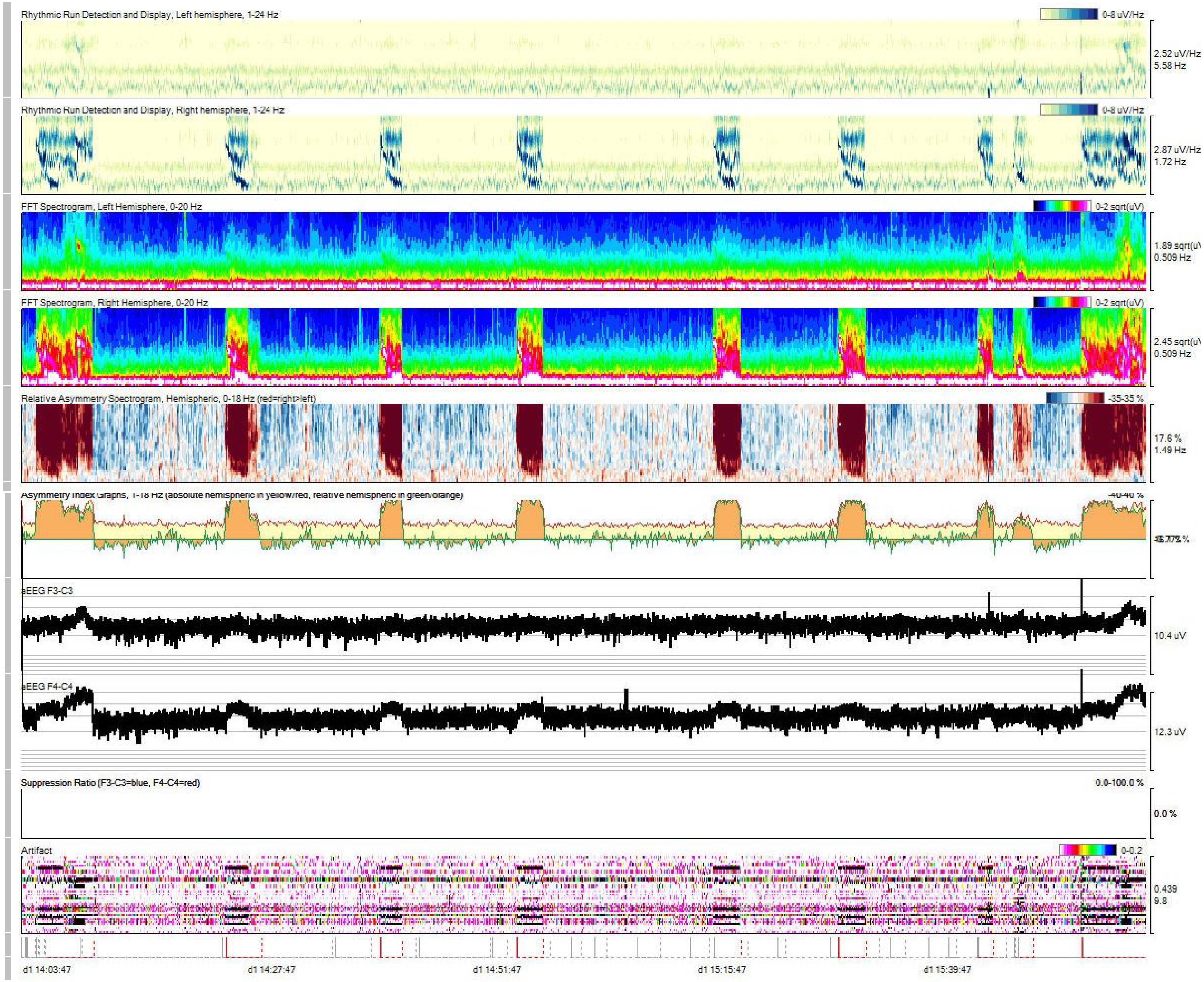


FP1-F3
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
F3-C3
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
C3-P3
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
P3-O1
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
FP2-F4
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
F4-C4
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
C4-P4
0.036 mm/uV
(640uV p-p)
0.5-30 Hz
P4-O2
0.036 mm/uV
(640uV p-p)
0.5-30 Hz

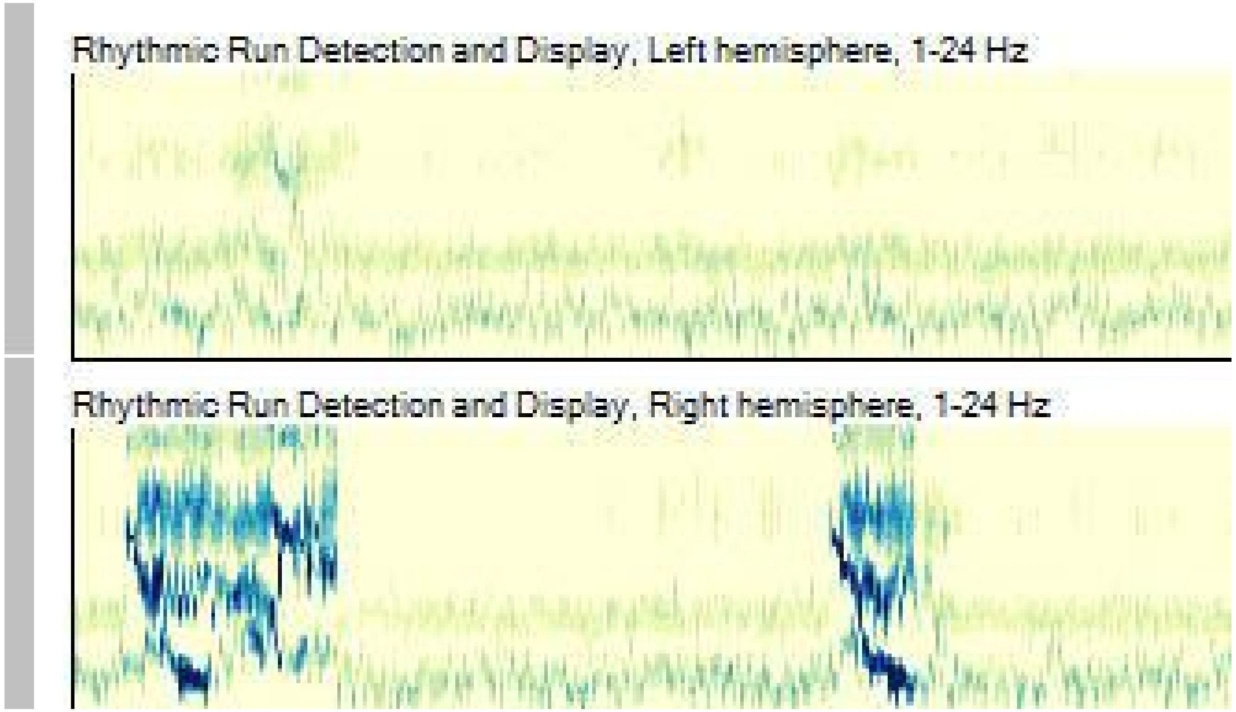


FOCAL SEIZURE ON RIGHT

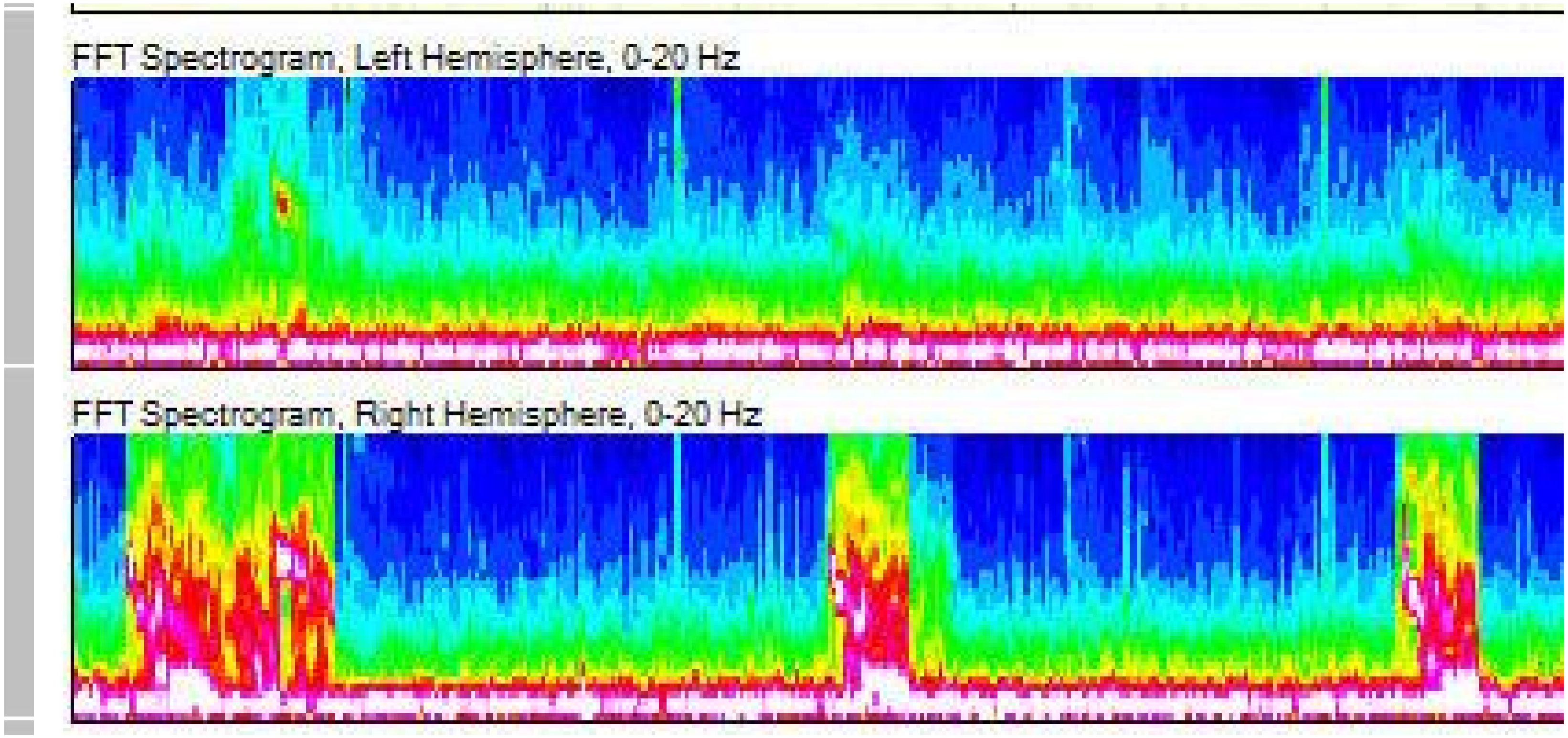




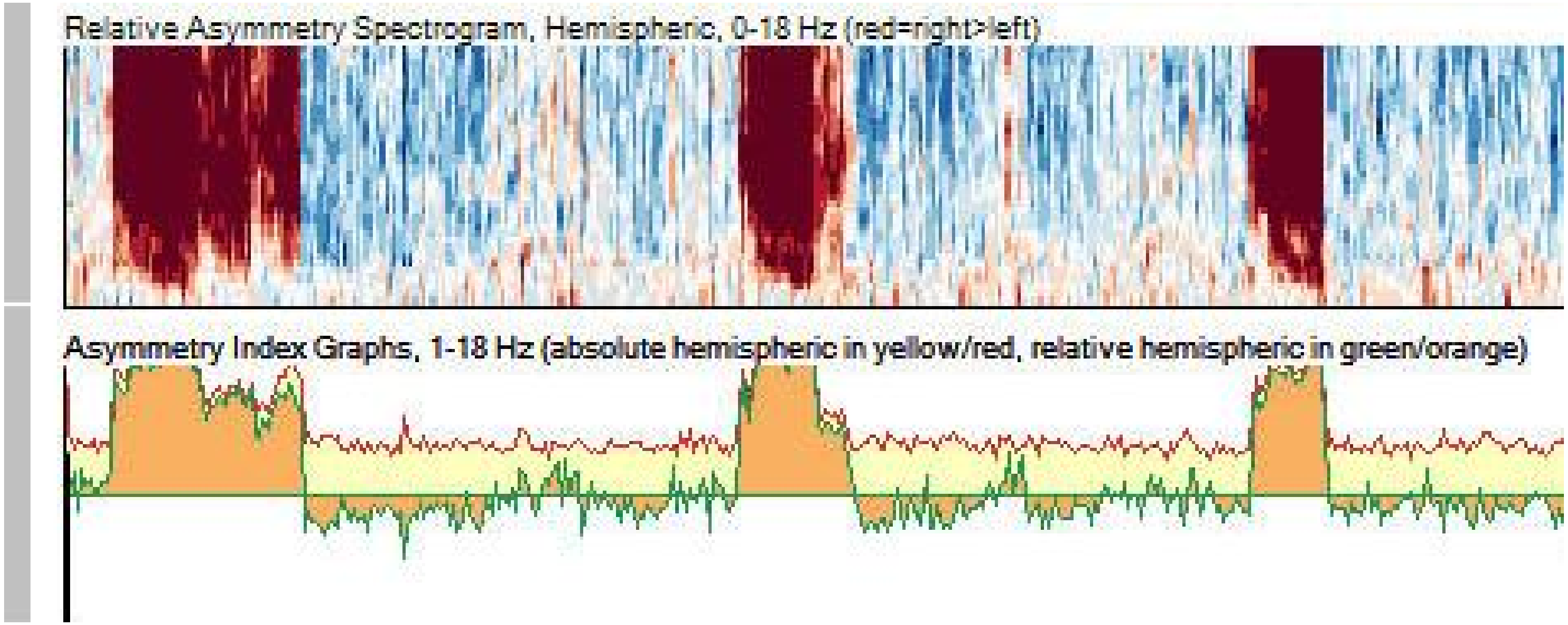
Rhythmic Run Detection and Display, Left hemisphere, 1-24 Hz
0-8 uV/Hz
2.52 uV/Hz
5.58 Hz
Rhythmic Run Detection and Display, Right hemisphere, 1-24 Hz
0-8 uV/Hz
2.87 uV/Hz
1.72 Hz
FFT Spectrogram, Left Hemisphere, 0-20 Hz
0-2 sqrt(uV)
1.89 sqrt(uV
0.509 Hz
FFT Spectrogram, Right Hemisphere, 0-20 Hz
0-2 sqrt(uV)
2.45 sqrt(uV
0.509 Hz
Relative Asymmetry Spectrogram, Hemispheric, 0-18 Hz (red=right>left)
-35-35 %
17.6 %
1.49 Hz
Asymmetry Index Graphs, 1-18 Hz (absolute hemispheric in yellow/red, relative hemispheric in green/orange)
-40-40 %
aEEG F3-C3
10.4 uV
aEEG F4-C4
12.3 uV
Suppression Ratio (F3-C3=blue, F4-C4=red)
0.0-100.0 %
0.0 %
Artifact
0-0.2
0.439
9.8
d1 14:03:47
d1 14:27:47
d1 14:51:47
d1 15:15:47
d1 15:39:47


Rhythmic Run Detection and Display, Left hemisphere, 1-24 Hz
Rhythmic Run Detection and Display, Right hemisphere, 1-24 Hz

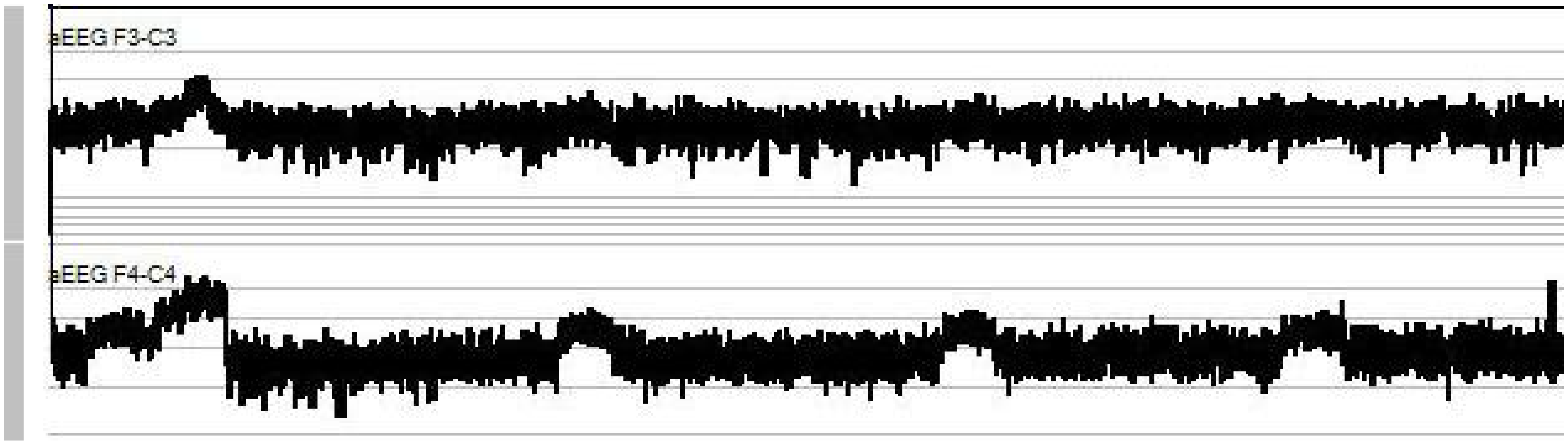
FAST FOURIER TRANSFORM SPECTRA



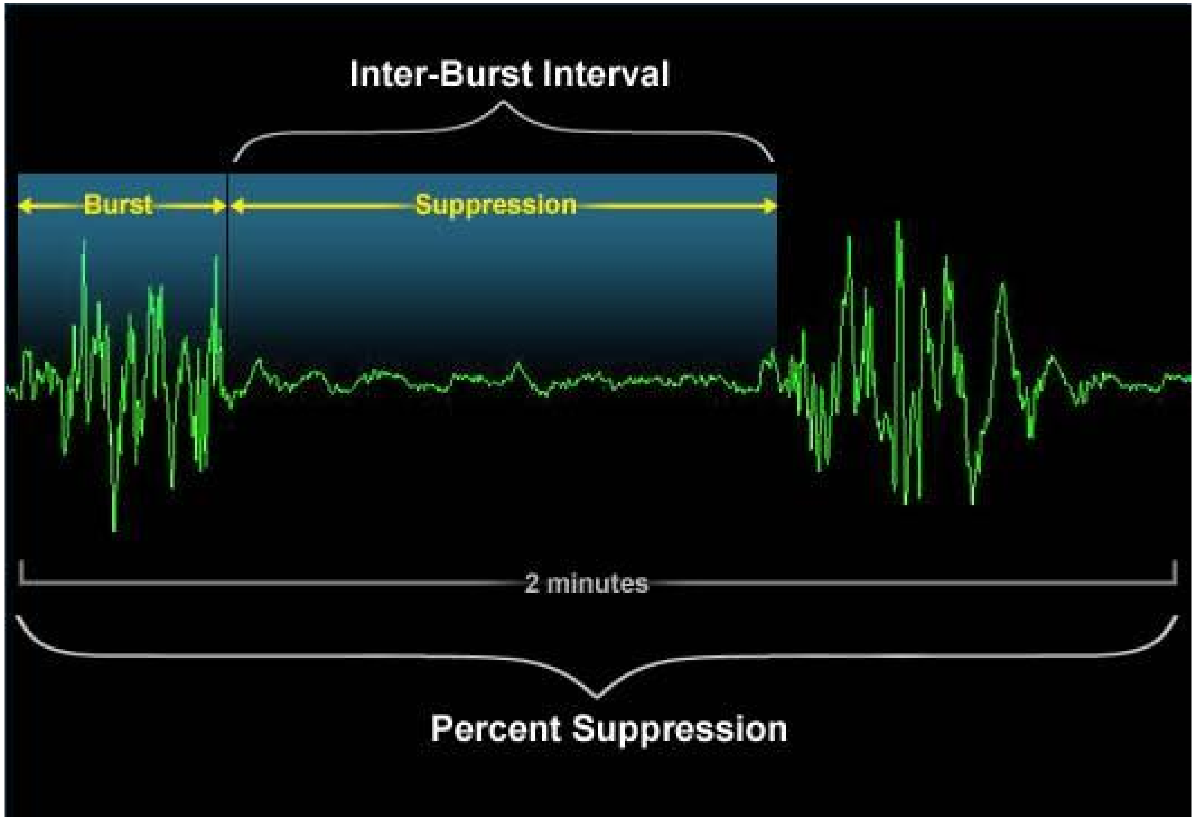
ASYMMETRY MEASUREMENTS



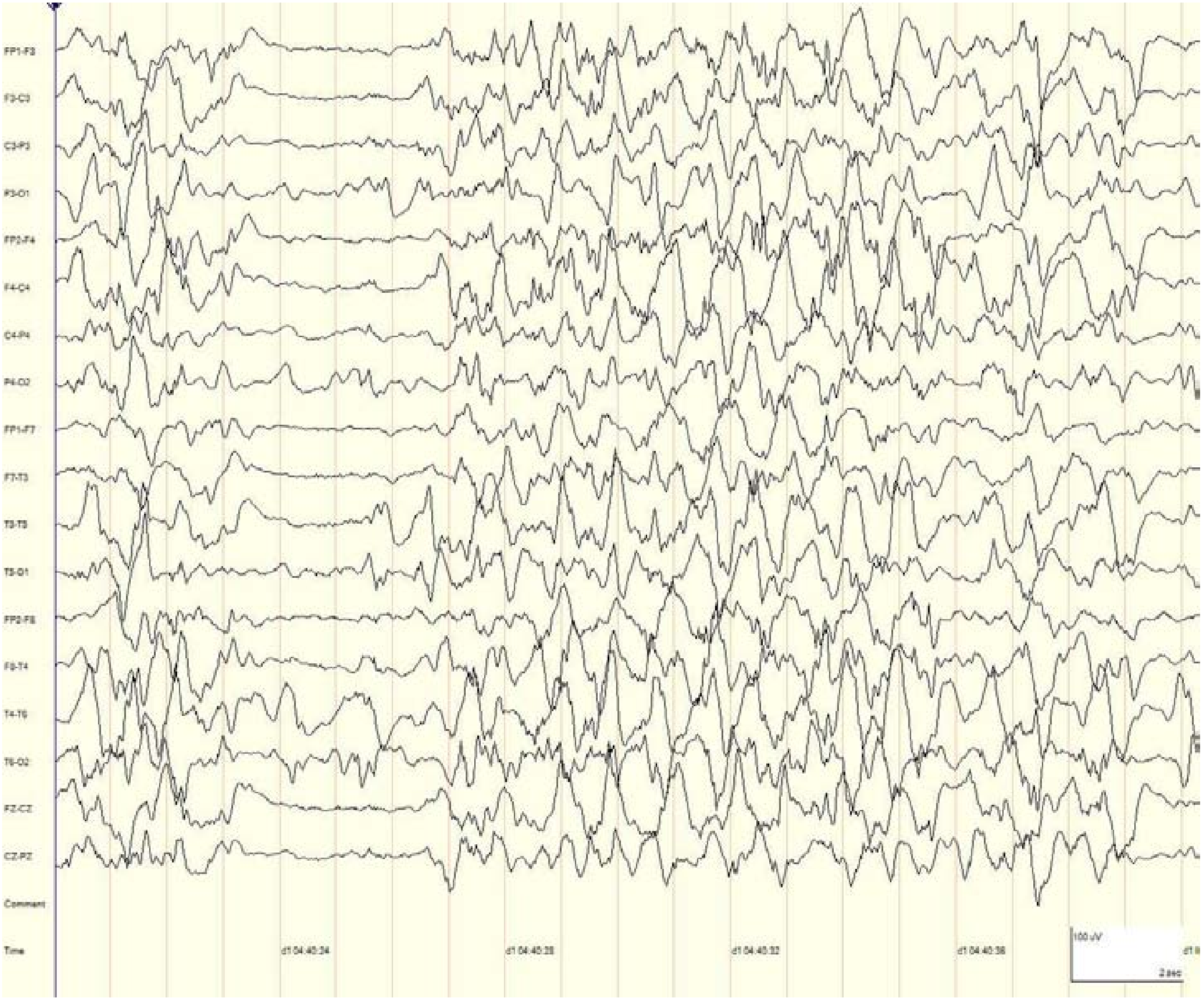
Amplitude integrated EEG



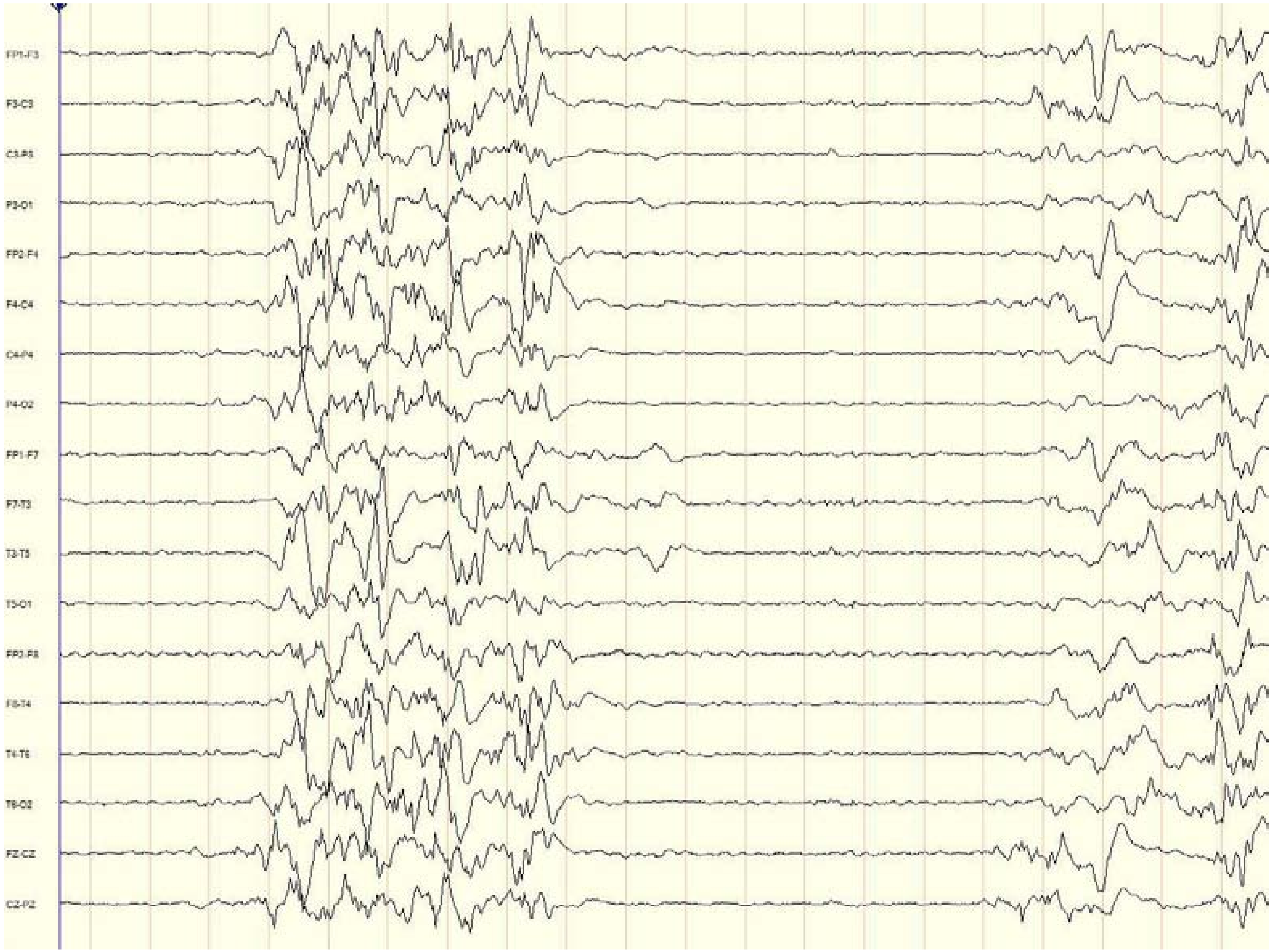
Burst Suppression Indices

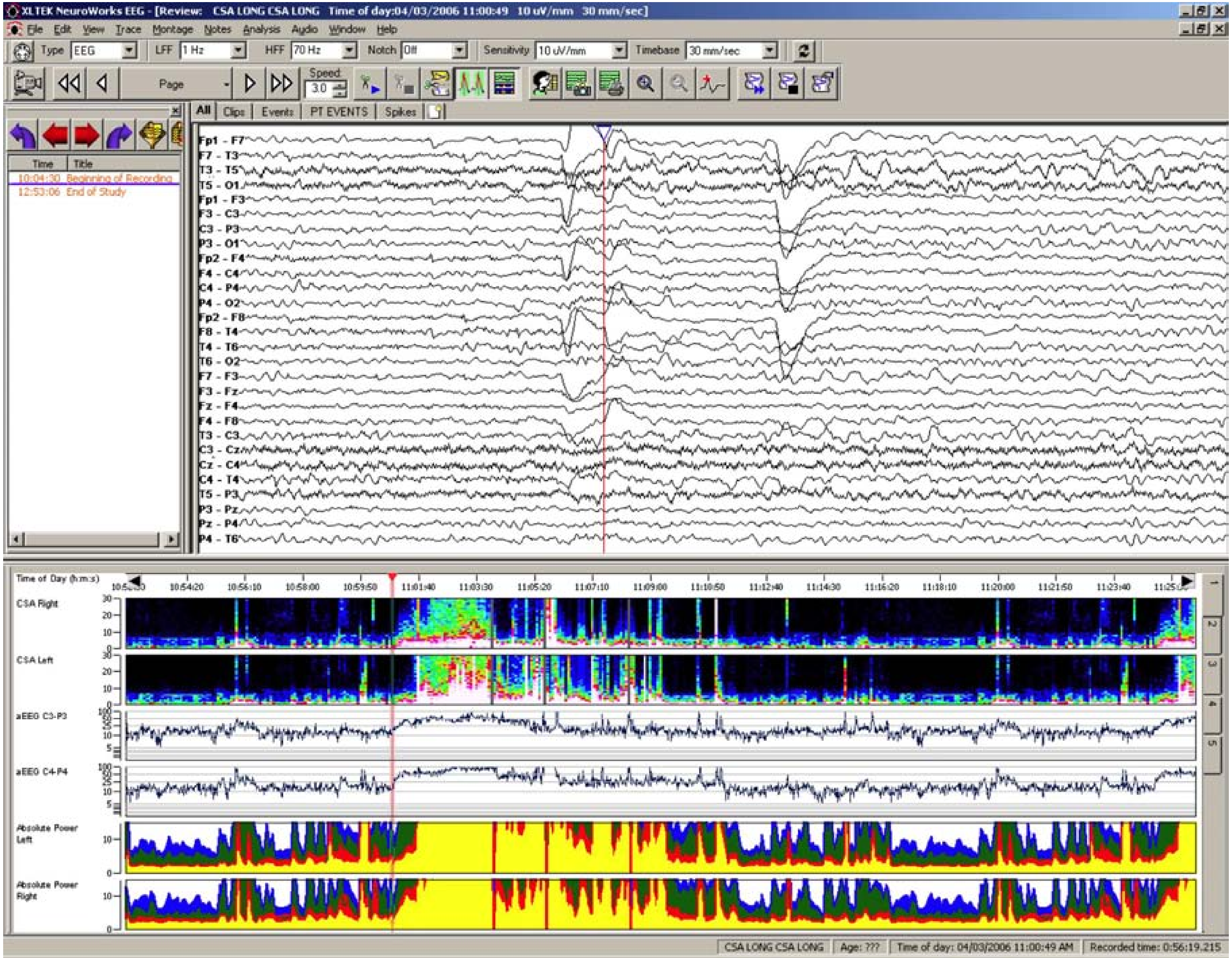


BRIEF SUPPRESSION



SUPPRESSION-BURST

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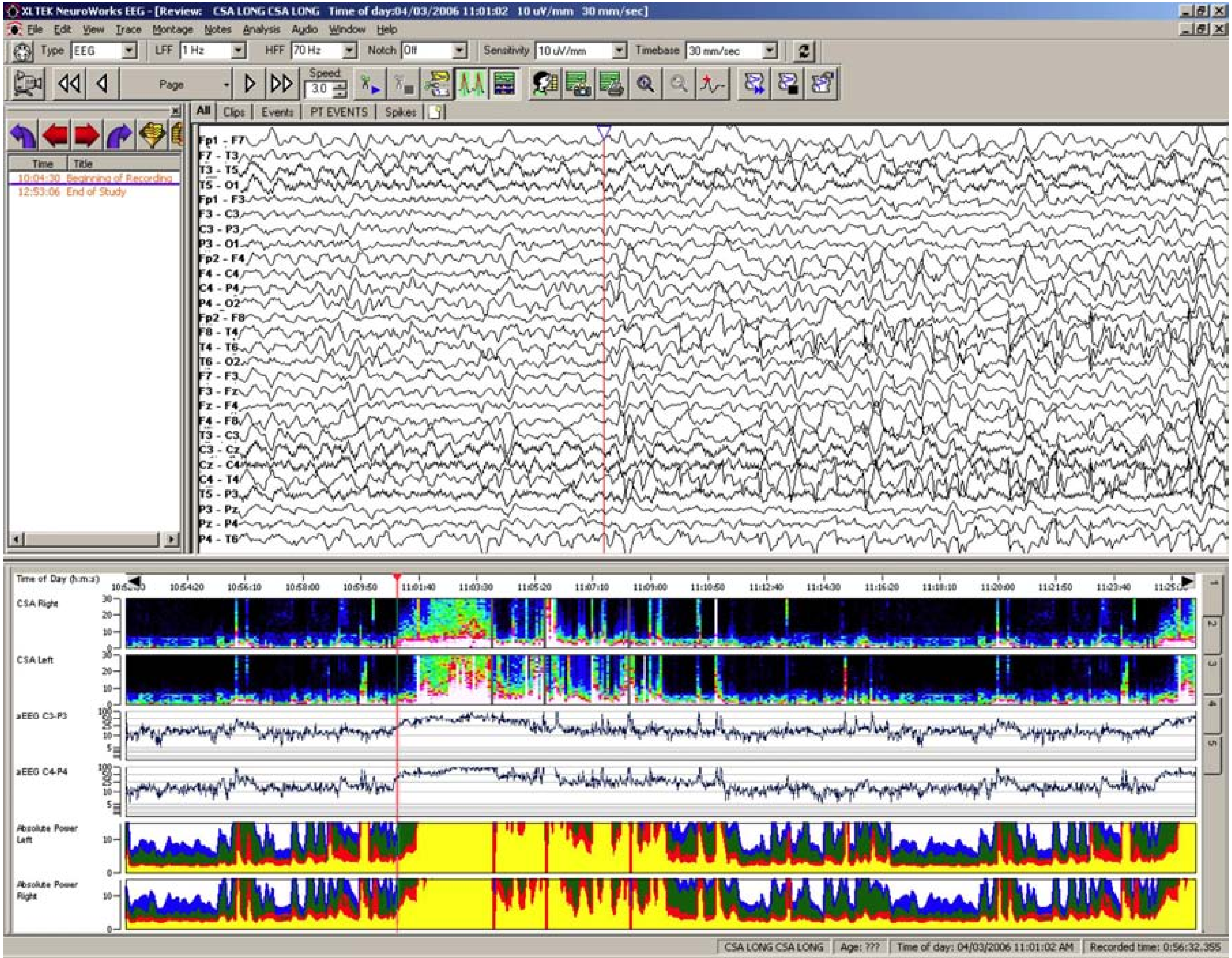
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG LFF 1 Hz HFF 70 Hz Notch Off Sensitivity 10 uV/mm Timebase 30 mm/sec
Page Speed 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
10:54:20 10:56:10 10:58:00 10:59:50 11:01:40 11:03:30 11:05:20 11:07:10 11:09:00 11:10:50 11:12:40 11:14:30 11:16:20 11:18:10 11:20:00 11:21:50 11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG Age: ??? Time of day: 04/03/2006 11:00:49 AM Recorded time: 0:56:19.215


XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:01:02 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG LFF 1 Hz HFF 70 Hz Notch Off Sensitivity 10 uV/mm Timebase 30 mm/sec
Page
Speed 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
10:54:20
10:56:10
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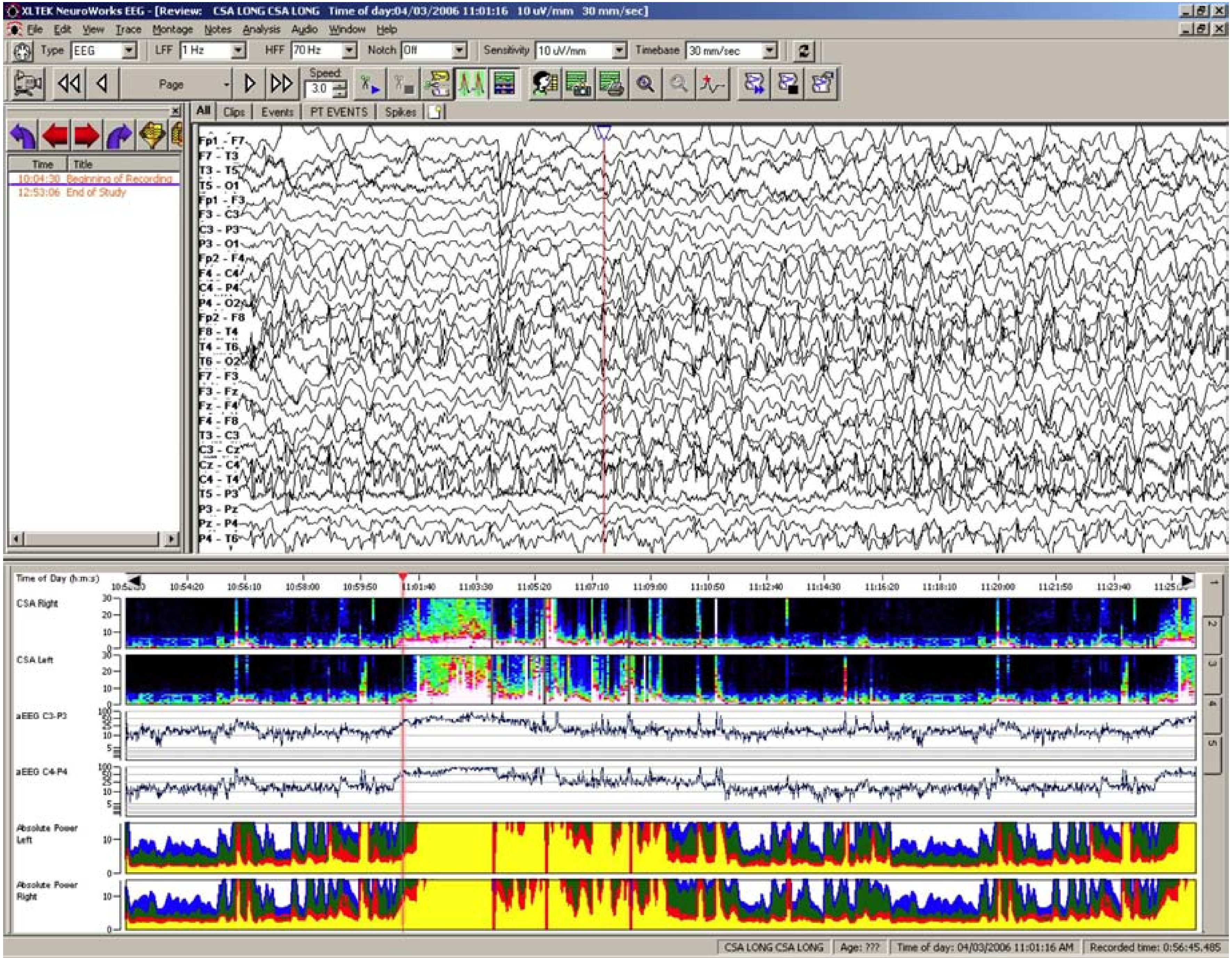
11:03:30
11:05:20
11:07:10
11:09:00
11:10:50
11:12:40
11:14:30
11:16:20
11:18:10
11:20:00
11:21:50
11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:01:02 AM
Recorded time: 0:56:32.355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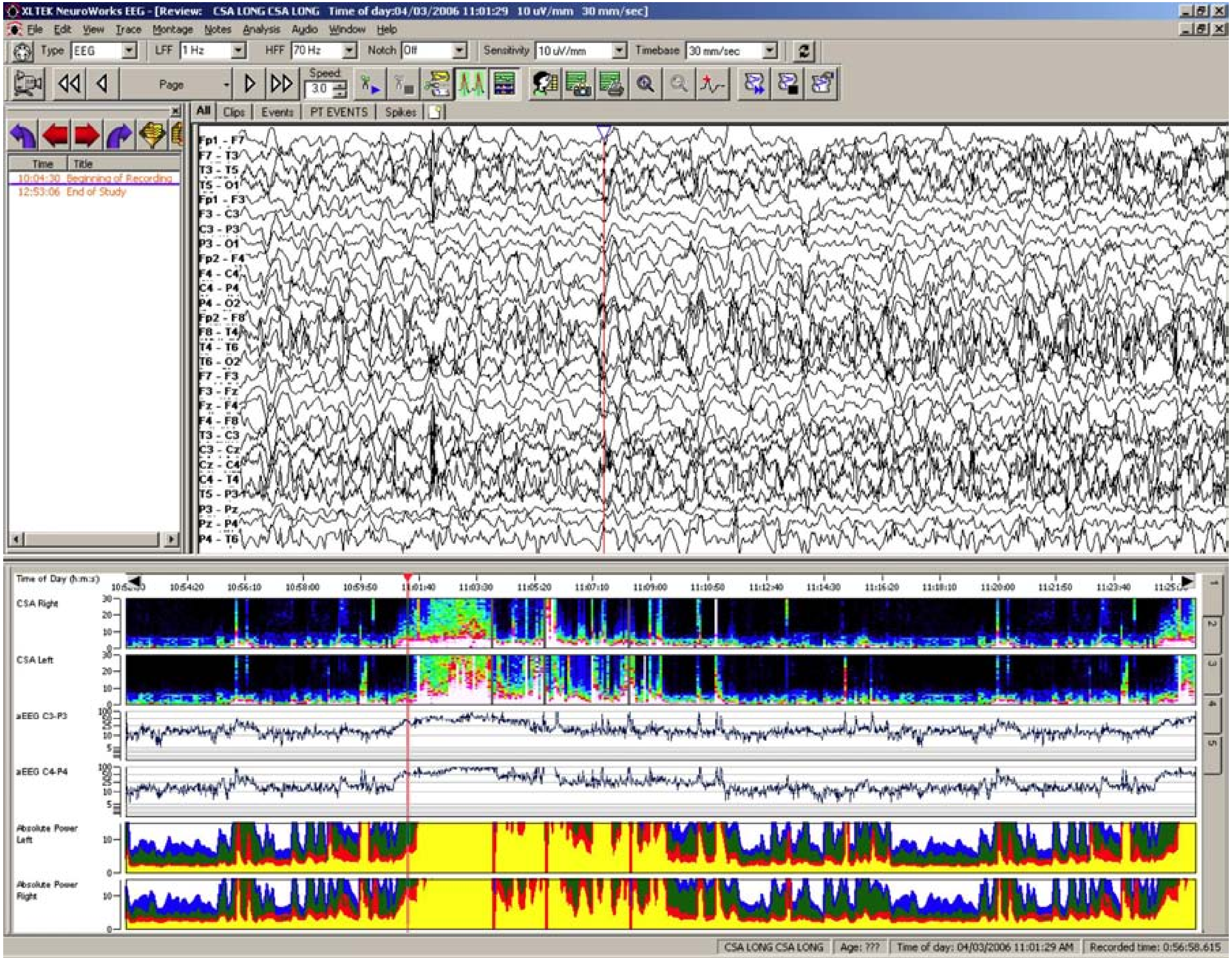
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
10:54:20 10:56:10 10:58:00 10:59:50 11:01:40 11:03:30 11:05:20 11:07:10 11:09:00 11:10:50 11:12:40 11:14:30 11:16:20 11:18:10 11:20:00 11:21:50 11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:01:16 AM
Recorded time: 0:56:45.485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File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG
LFF 1 Hz
HFF 70 Hz
Notch Off
Sensitivity 10 uV/mm
Timebase 30 mm/sec
Page
Speed 3.0
All
Clips
Events
PT EVENTS
Spikes
Time
Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
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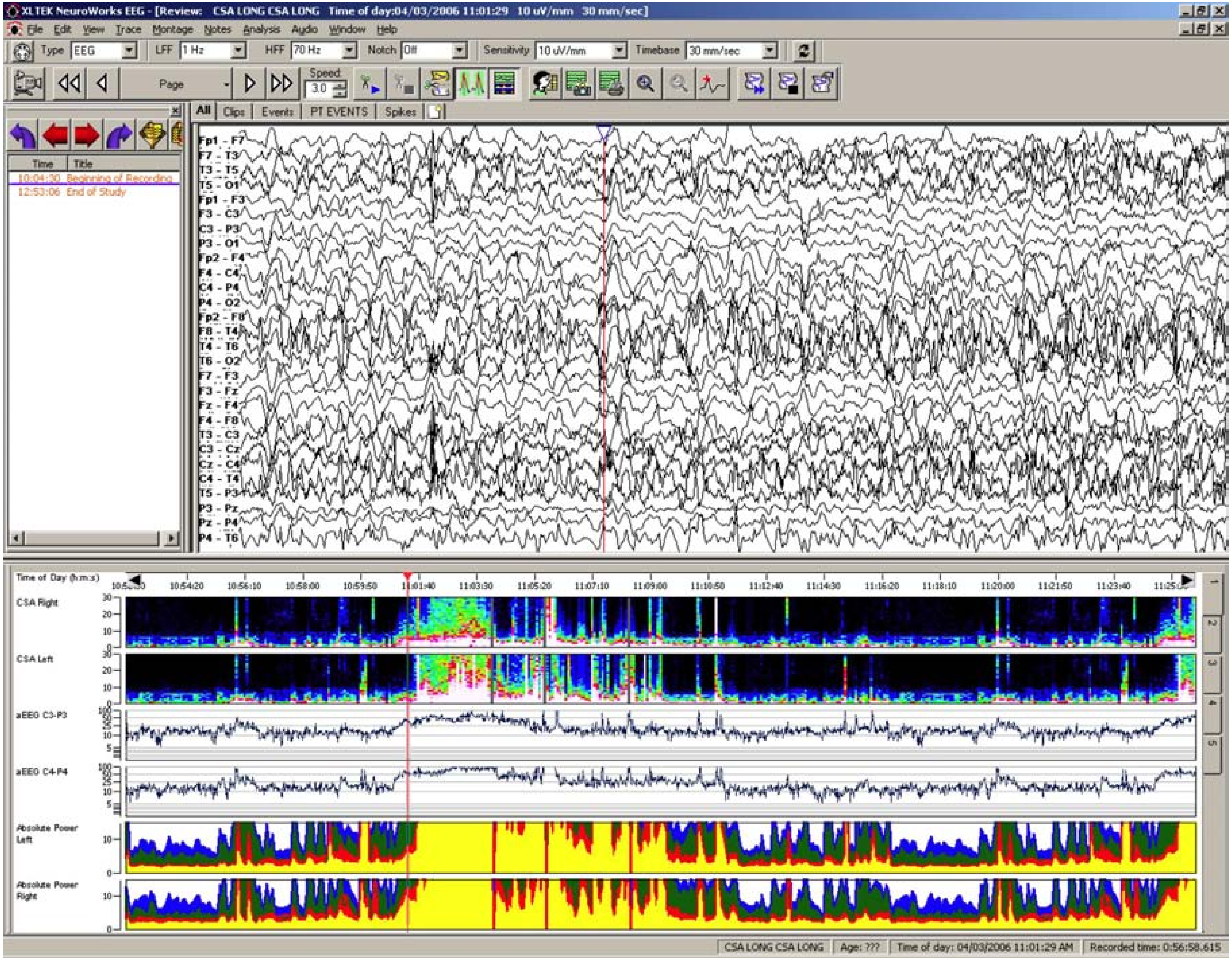
11:03:30
11:05:20
11:07:10
11:09:00
11:10:50
11:12:40
11:14:30
11:16:20
11:18:10
11:20:00
11:21:50
11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:01:29 AM
Recorded time: 0:56:58.615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HFF 70 Hz
Notch Off
Sensitivity 10 uV/mm
Timebase 30 mm/sec
Page
Speed: 3.0
All
Clips
Events
PT EVENTS
Spikes
Time
Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
10:54:20
10:56:10
10:58:00
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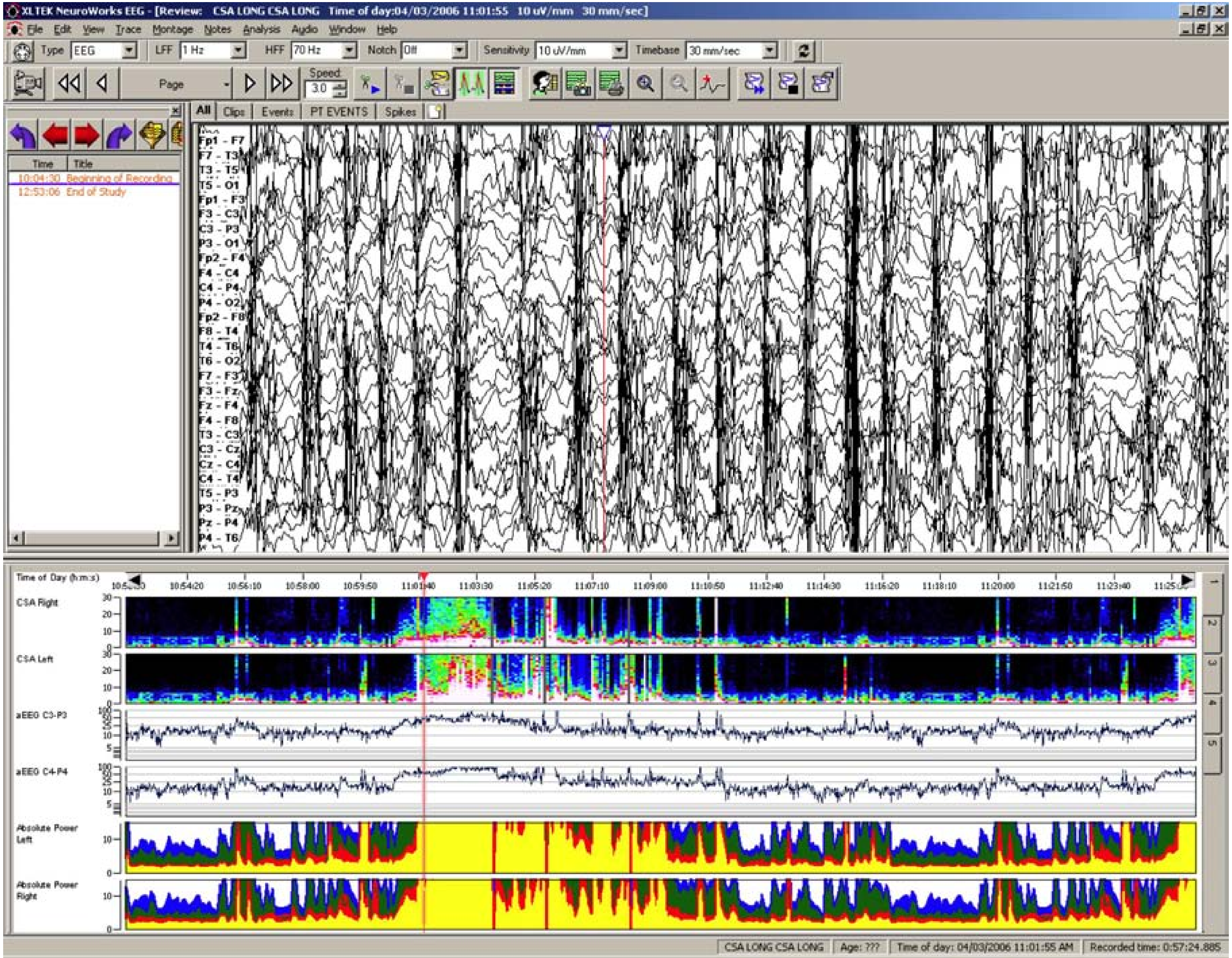
11:03:30
11:05:20
11:07:10
11:09:00
11:10:50
11:12:40
11:14:30
11:16:20
11:18:10
11:20:00
11:21:50
11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:01:29 AM
Recorded time: 0:56:58.615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Type EEG LFF 1 Hz HFF 70 Hz Notch Off Sensitivity 10 uV/mm Timebase 30 mm/sec
Page
Speed 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
10:54:20 10:56:10 10:58:00 10:59:50 11:01:40 11:03:30 11:05:20 11:07:10 11:09:00 11:10:50 11:12:40 11:14:30 11:16:20 11:18:10 11:20:00 11:21:50 11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
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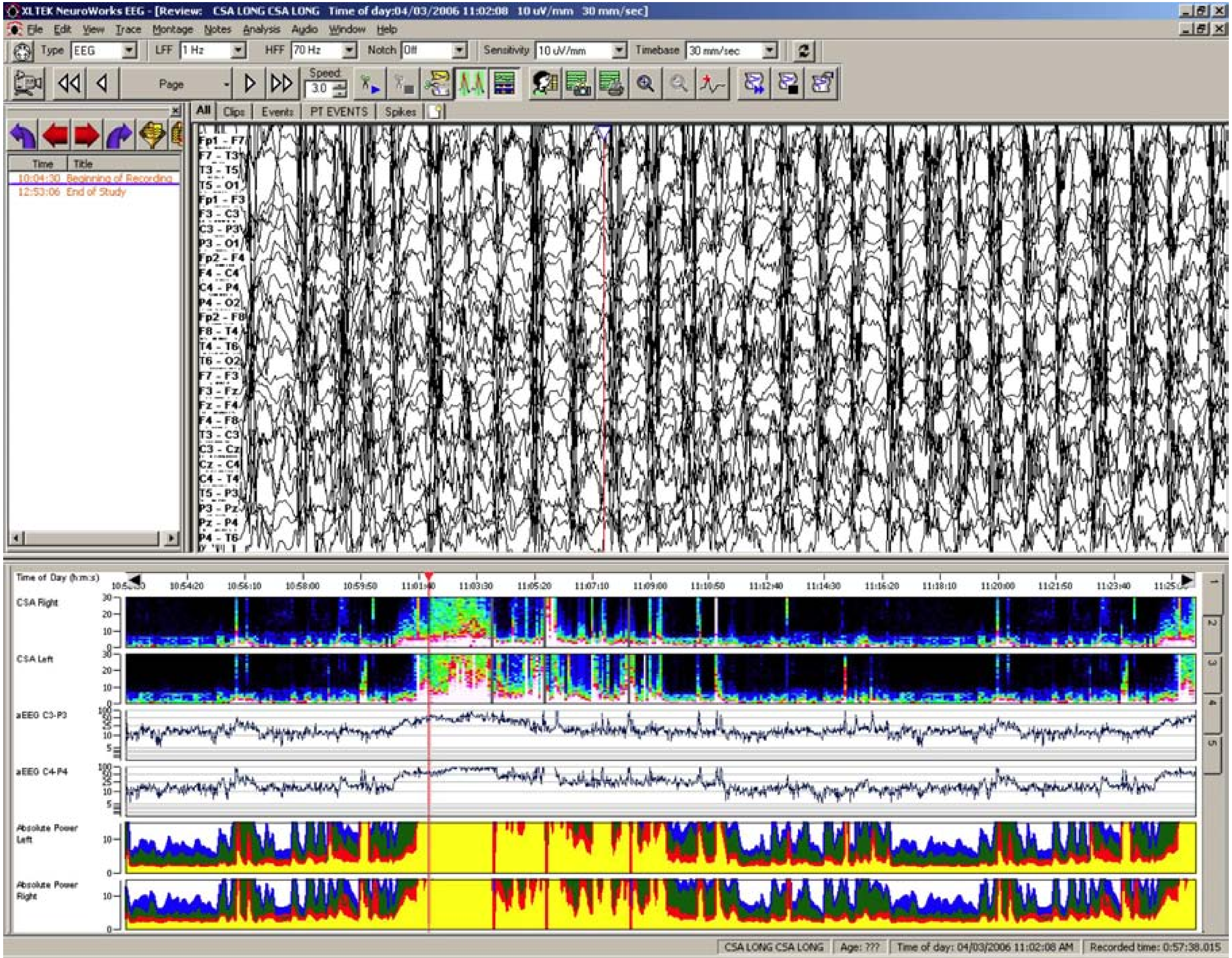
Recorded time: 0:57:24.885



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Page Speed 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Time of Day (h:m:s)
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
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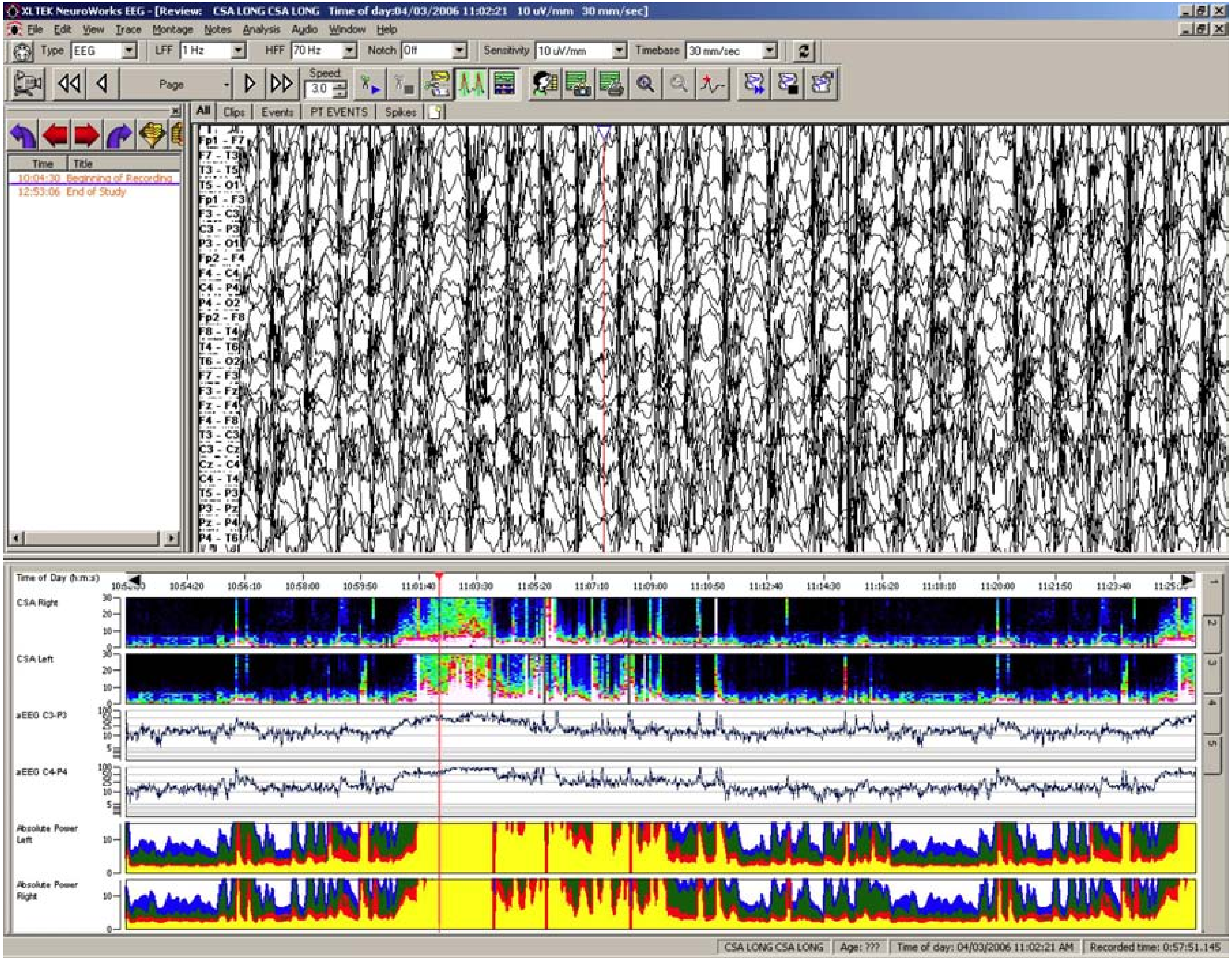
Recorded time: 0:57:38.015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Page Speed 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Time of Day (h:m:s)
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
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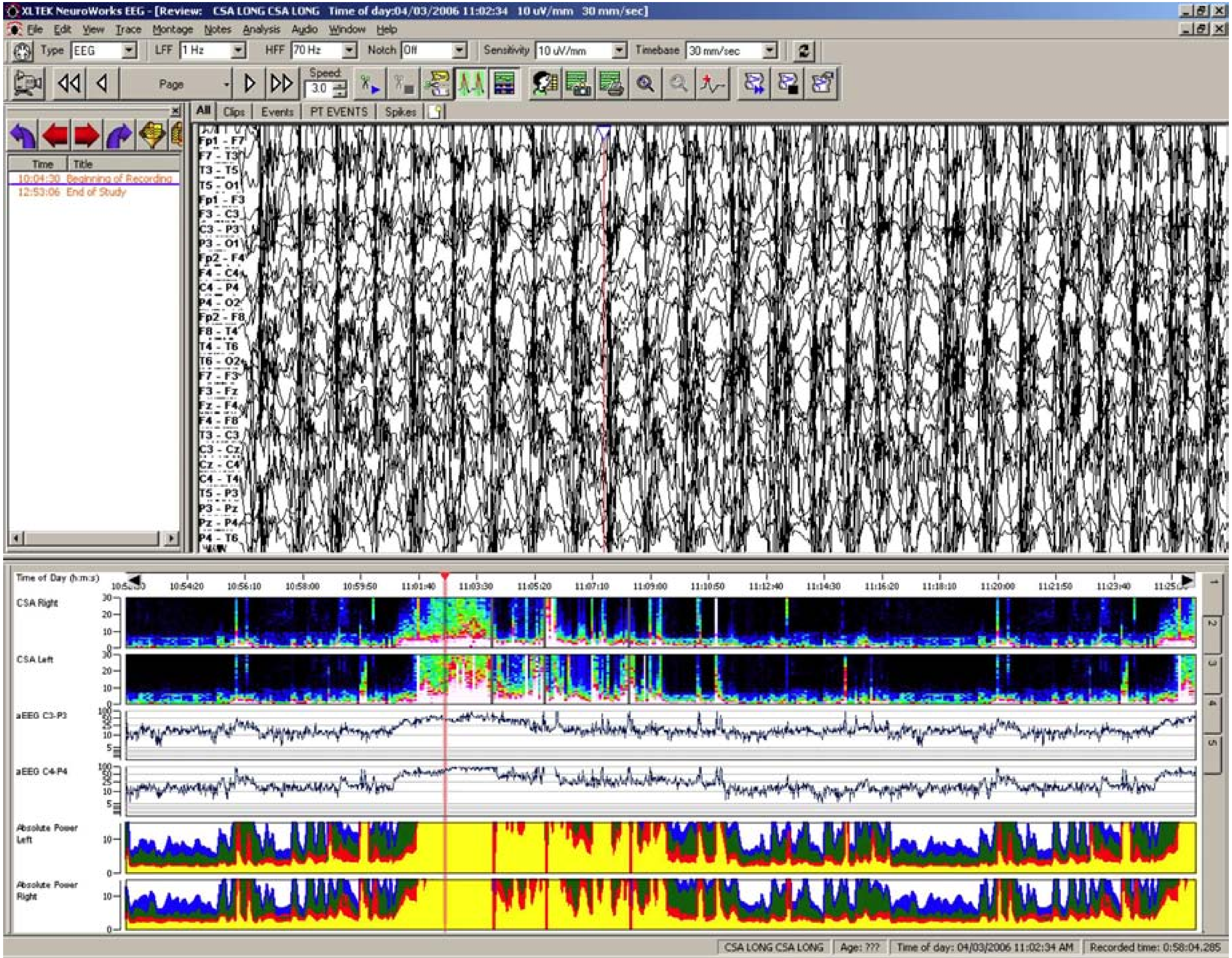
Recorded time: 0:57:51.145



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Type EEG
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HFF 70 Hz
Notch Off
Sensitivity 10 uV/mm
Timebase 30 mm/sec
Page
Speed 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
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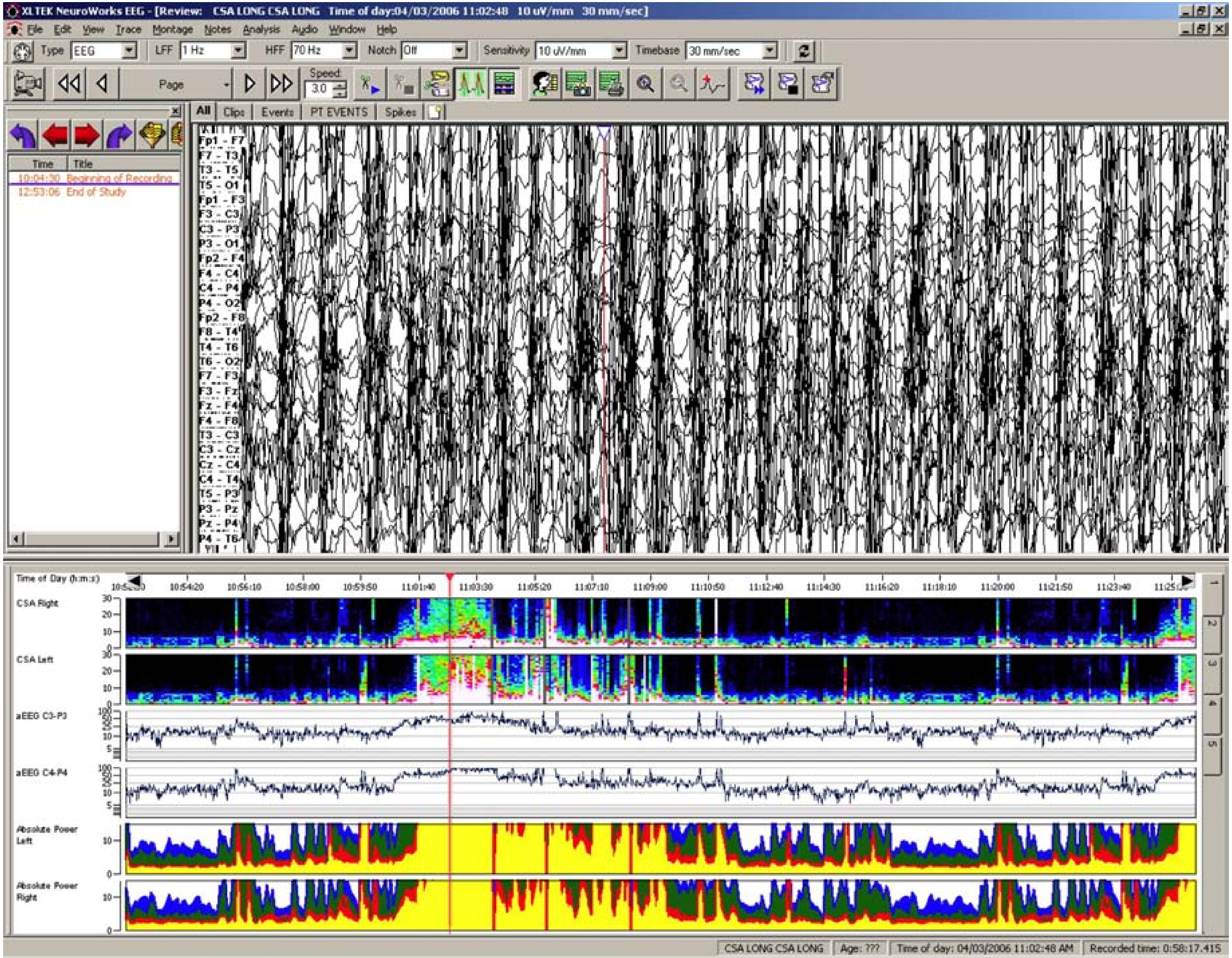
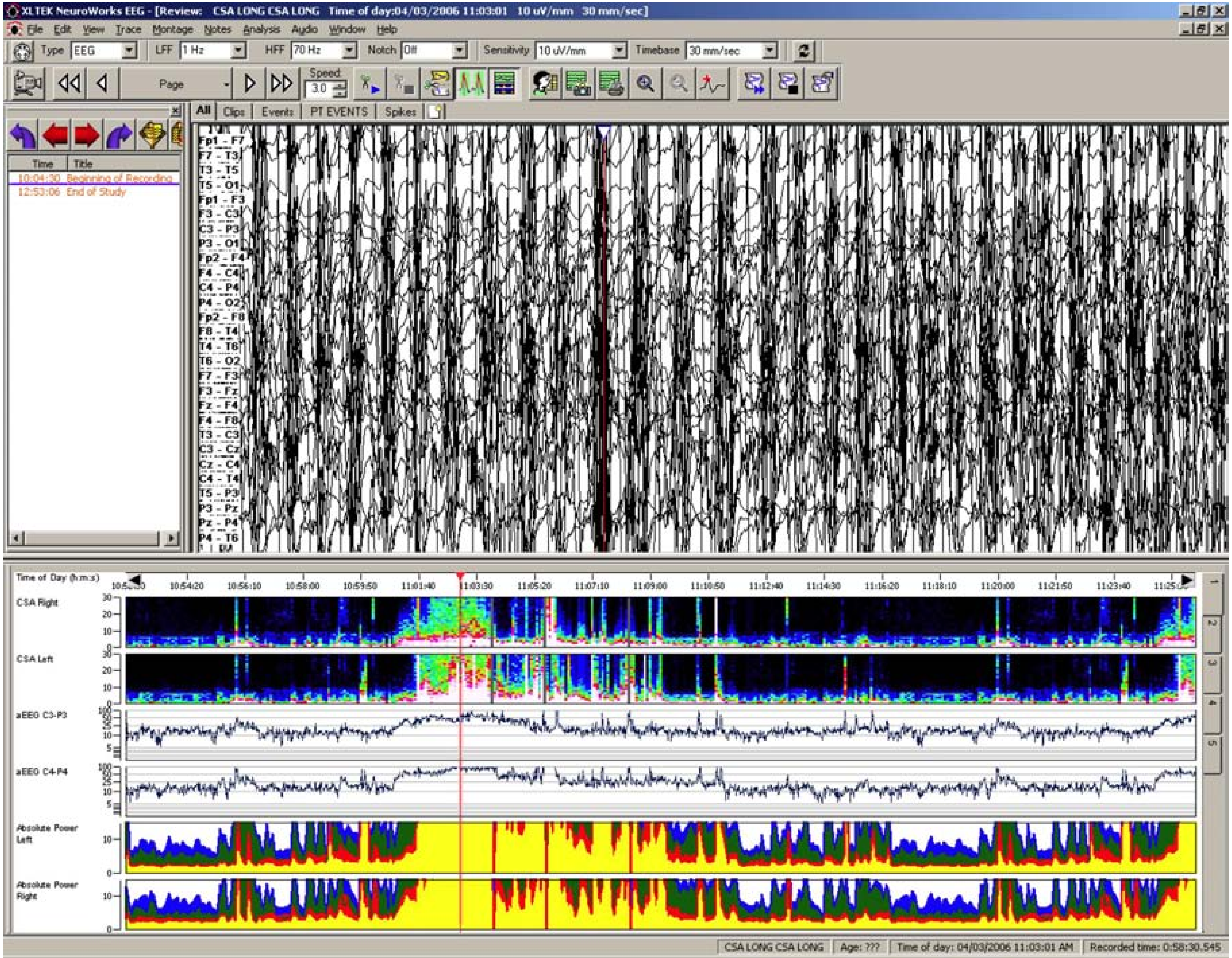
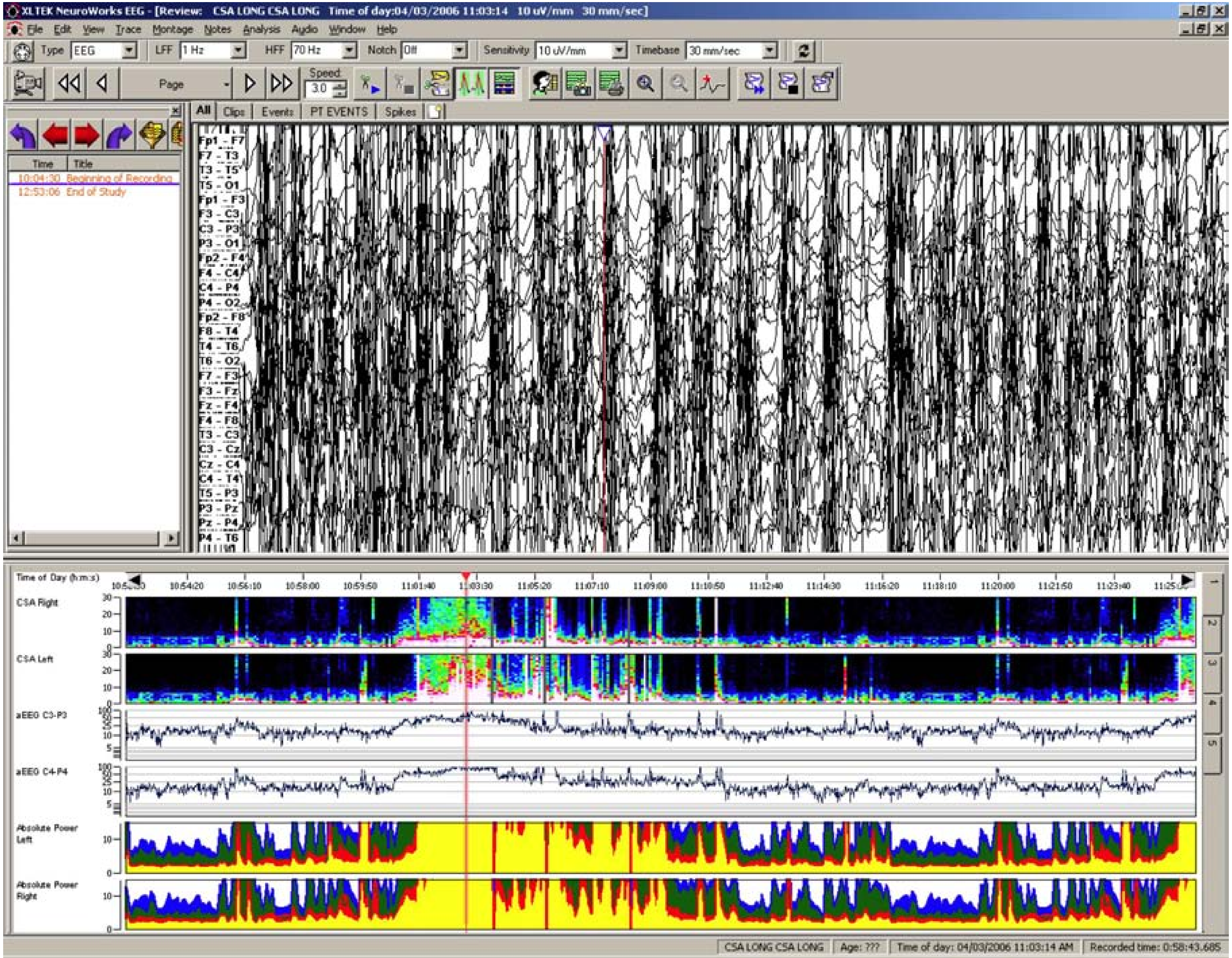
11:05:20
11:07:10
11:09:00
11:10:50
11:12:40
11:14:30
11:16:20
11:18:10
11:20:00
11:21:50
11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:02:34 AM
Recorded time: 0:58:04.285


XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:02:48 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG LFF 1 Hz HFF 70 Hz Notch Off Sensitivity 10 uV/mm Timebase 30 mm/sec
Page Speed: 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
10:54:20 10:56:10 10:58:00 10:59:50 11:01:40 11:03:30 11:05:20 11:07:10 11:09:00 11:10:50 11:12:40 11:14:30 11:16:20 11:18:10 11:20:00 11:21:50 11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:02:48 AM
Recorded time: 0:58:17.415


XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:03:01 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG LFF 1 Hz HFF 70 Hz Notch Off Sensitivity 10 uV/mm Timebase 30 mm/sec
Page Speed: 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
10:54:20 10:56:10 10:58:00 10:59:50 11:01:40 11:03:30 11:05:20 11:07:10 11:09:00 11:10:50 11:12:40 11:14:30 11:16:20 11:18:10 11:20:00 11:21:50 11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:03:01 AM
Recorded time: 0:58:30.545


XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:03:14 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG
LFF 1 Hz
HFF 70 Hz
Notch Off
Sensitivity 10 uV/mm
Timebase 30 mm/sec
Page
Speed: 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
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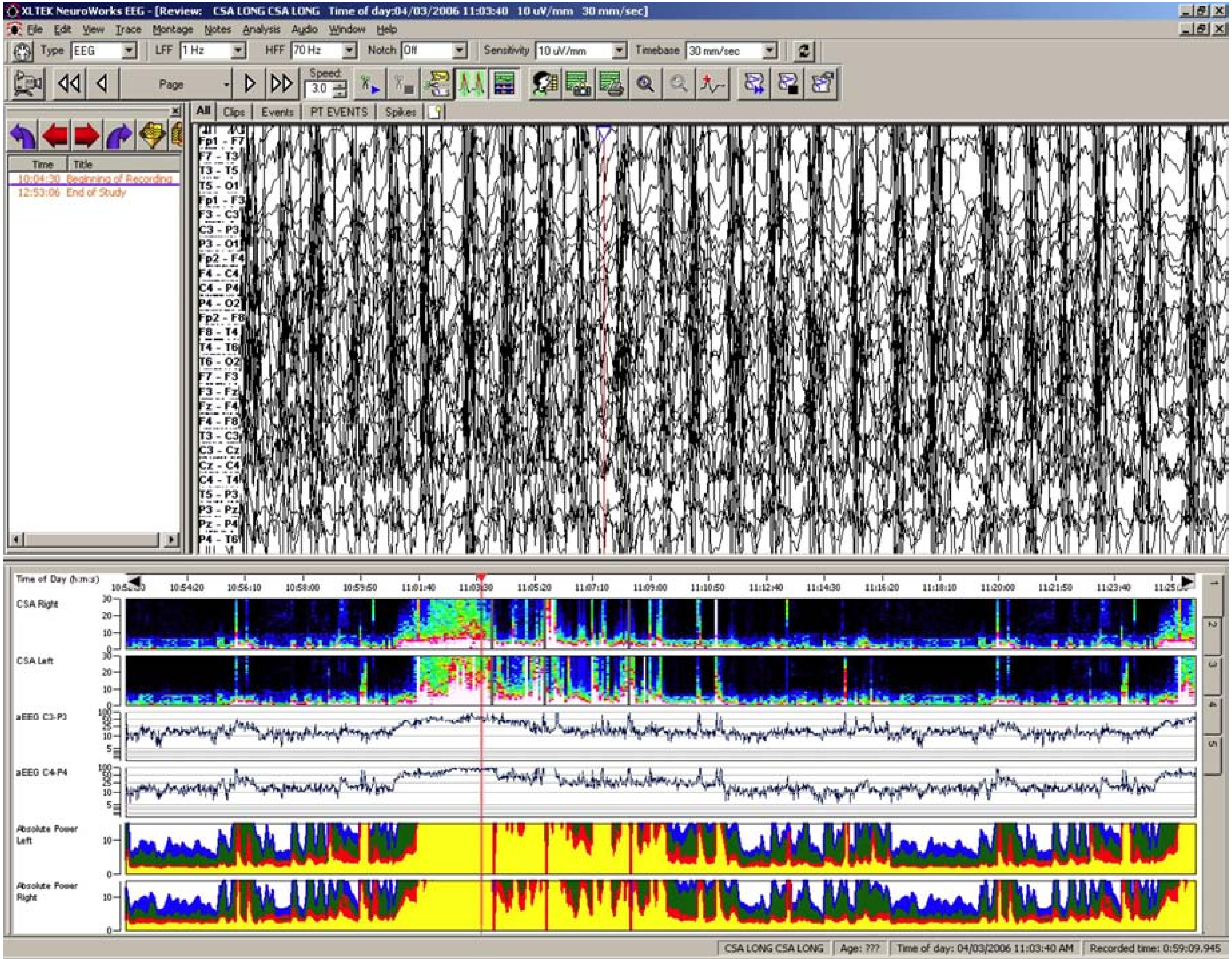
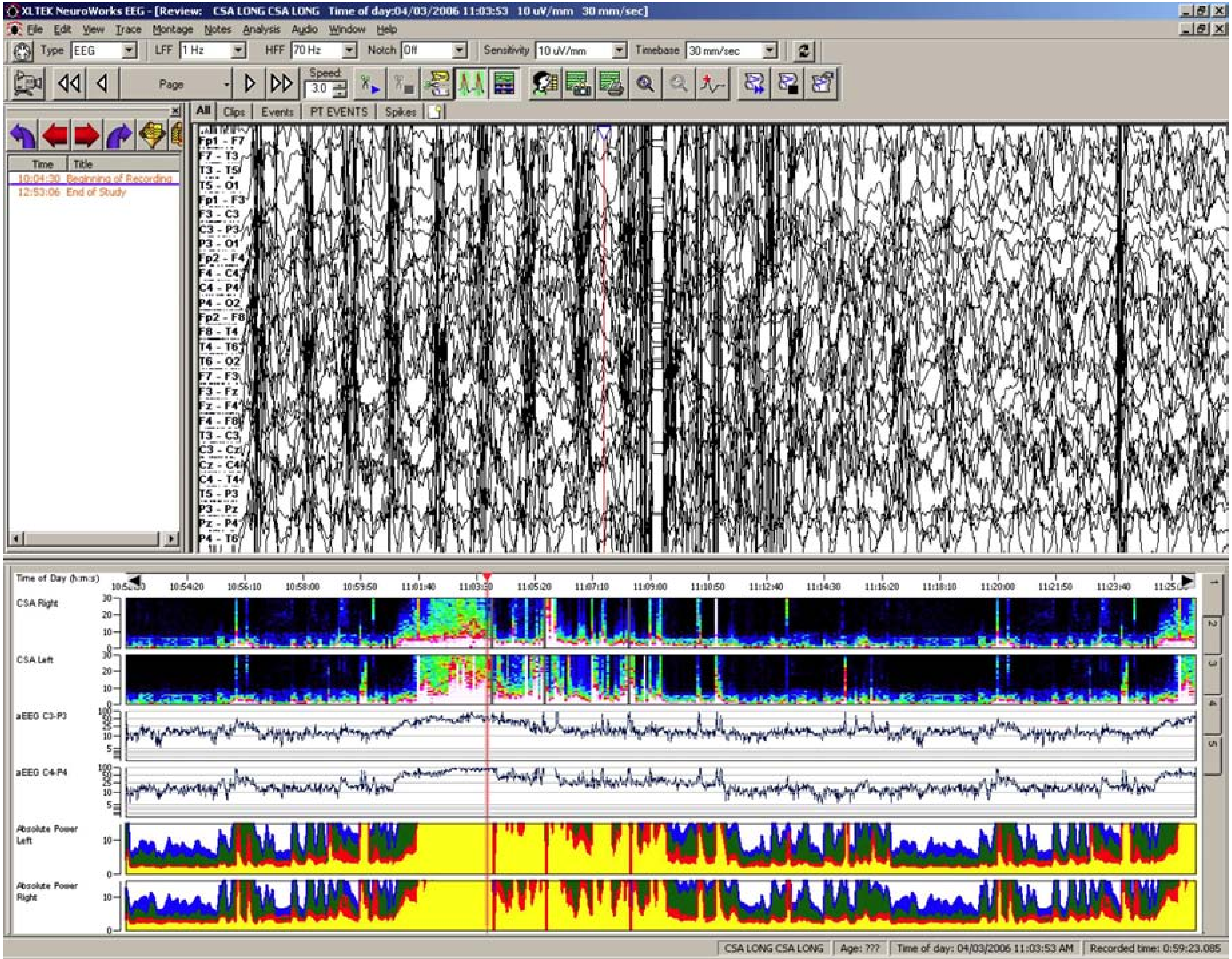
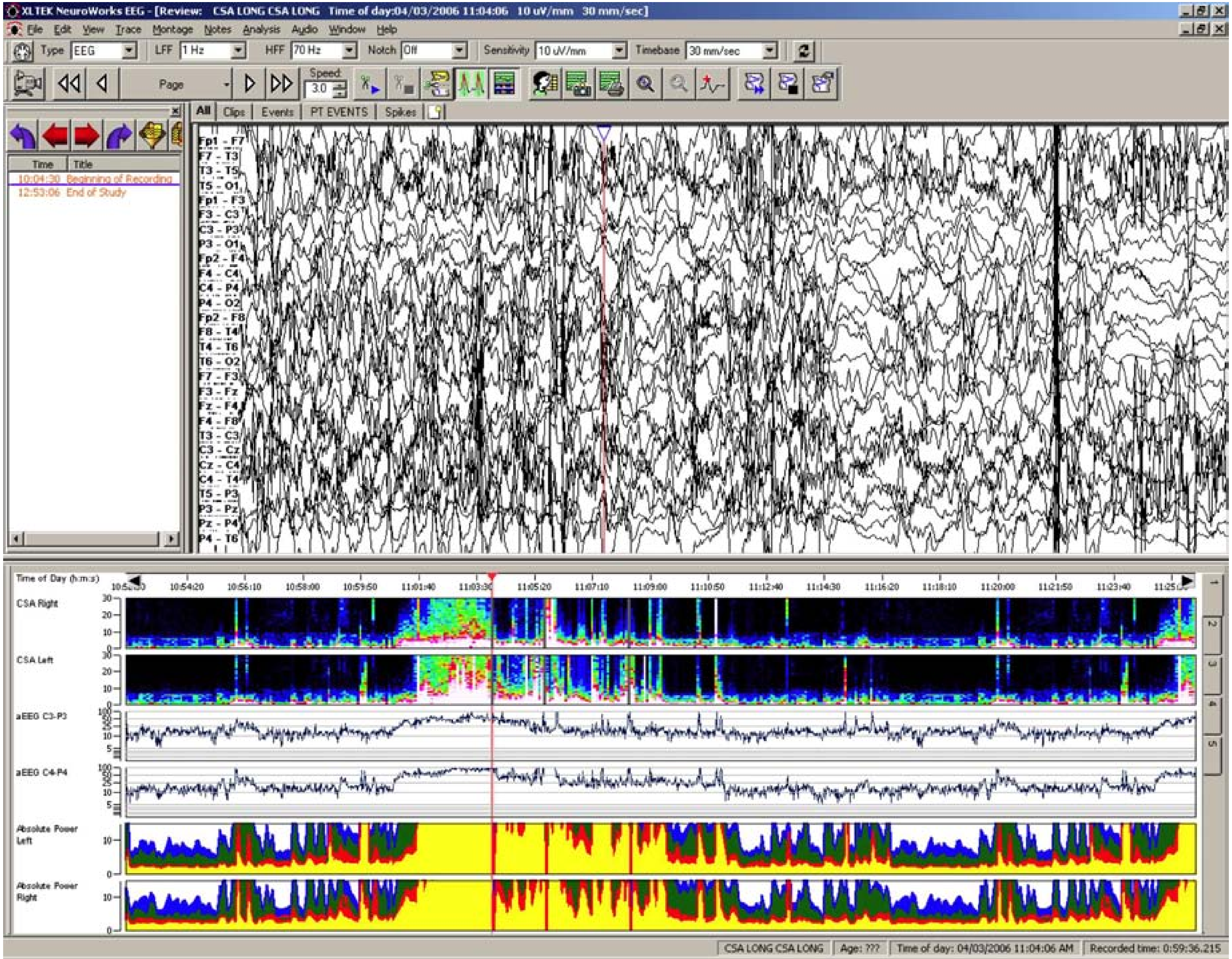
10:56:10
10:58:00
10:59:50
11:01:40
11:03:30
11:05:20
11:07:10
11:09:00
11:10:50
11:12:40
11:14:30
11:16:20
11:18:10
11:20:00
11:21:50
11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:03:14 AM
Recorded time: 0:58:43.685



XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:03:40 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG LFF 1 Hz HFF 70 Hz Notch Off Sensitivity 10 uV/mm Timebase 30 mm/sec
Page
Speed: 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Time of Day (h:m:s)
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:03:40 AM
Recorded time: 0:59:09.945


XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:03:53 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG
LFF 1 Hz
HFF 70 Hz
Notch Off
Sensitivity 10 uV/mm
Timebase 30 mm/sec
Page
Speed: 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
10:54:20
10:56:10
10:58:00
10:59:50
11:01:40
11:05:20
11:07:10
11:09:00
11:10:50
11:12:40
11:14:30
11:16:20
11:18:10
11:20:00
11:21:50
11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:03:53 AM
Recorded time: 0:59:23.085


XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:04:06 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG LFF 1 Hz HFF 70 Hz Notch Off Sensitivity 10 uV/mm Timebase 30 mm/sec
Page
Speed: 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
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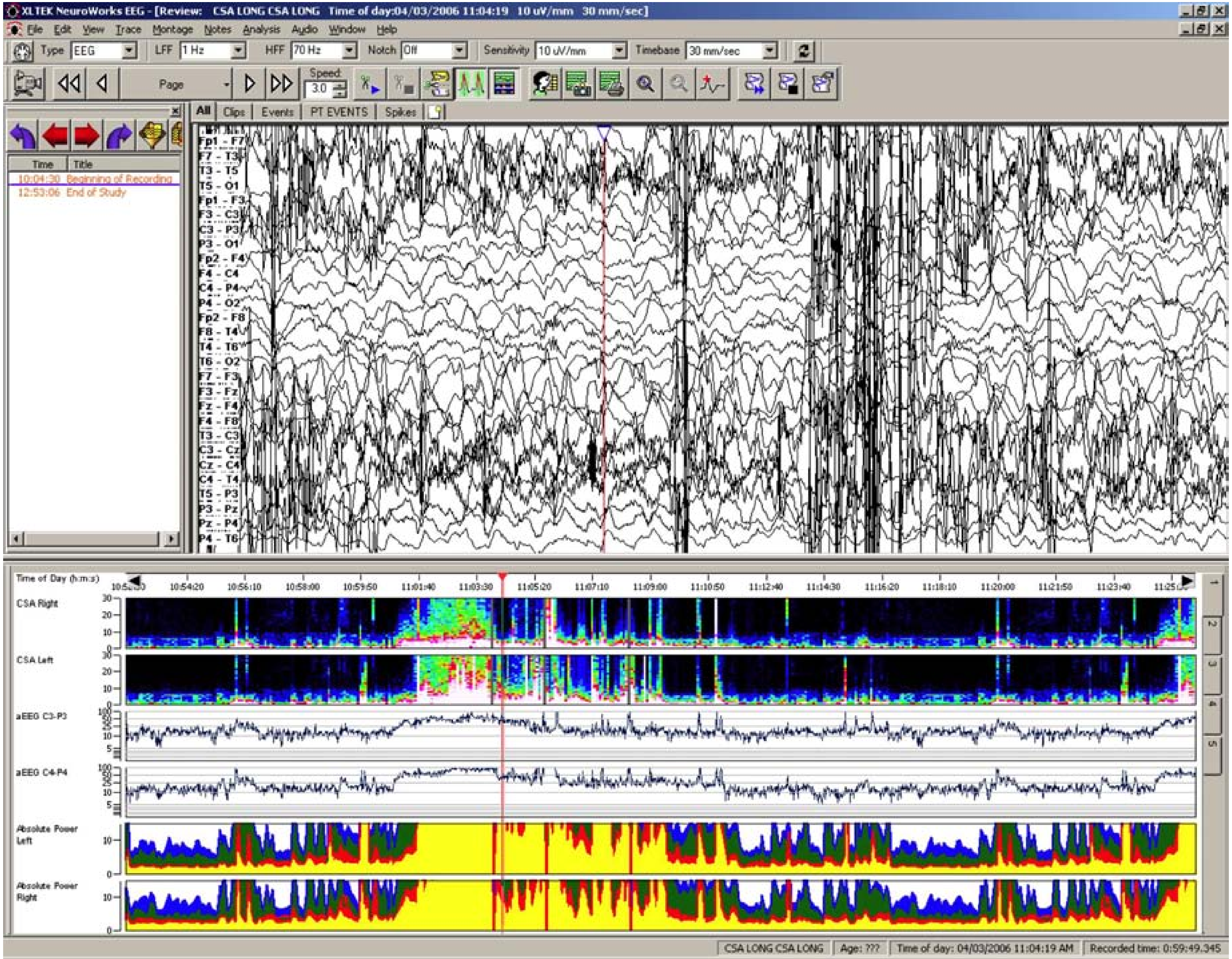
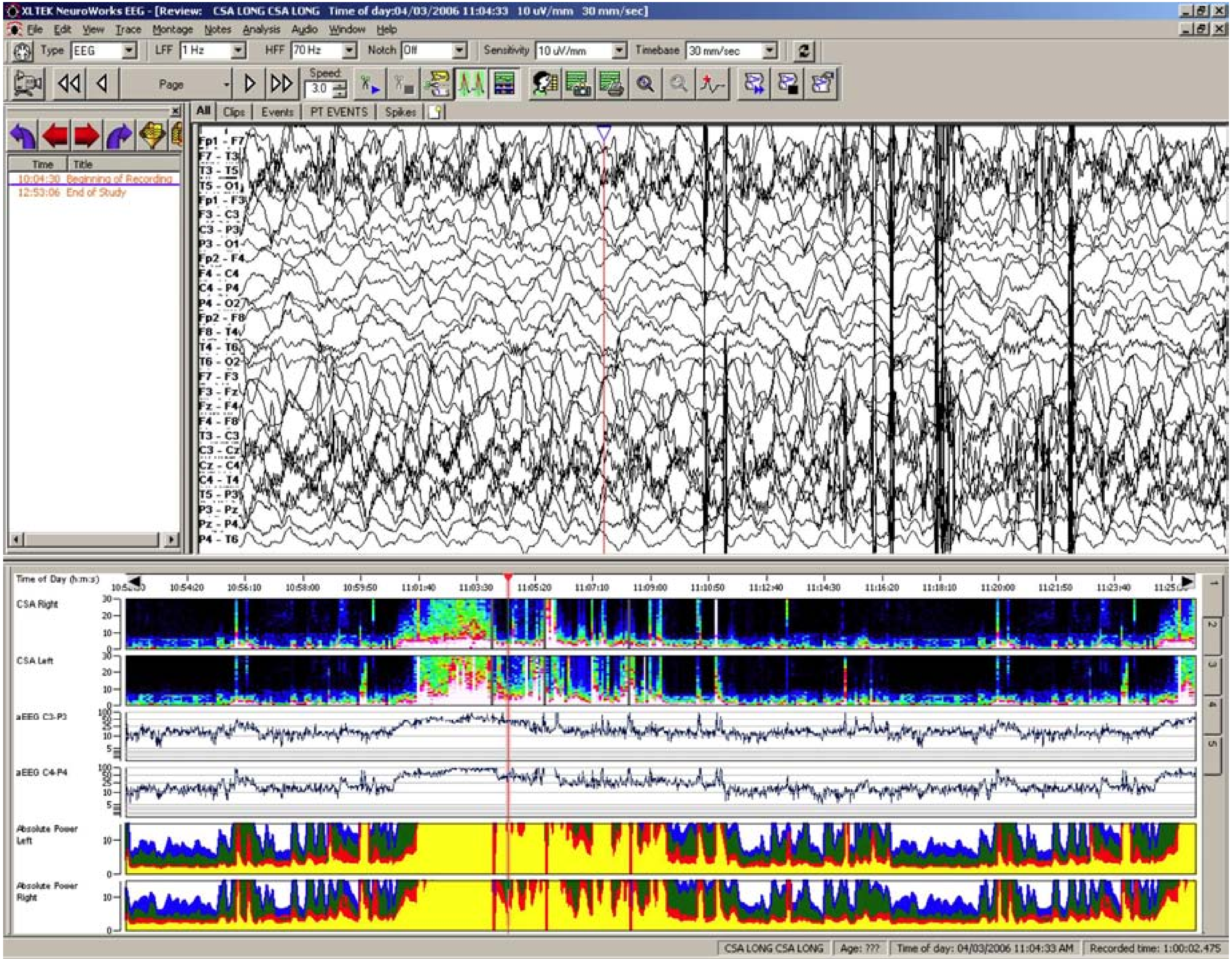
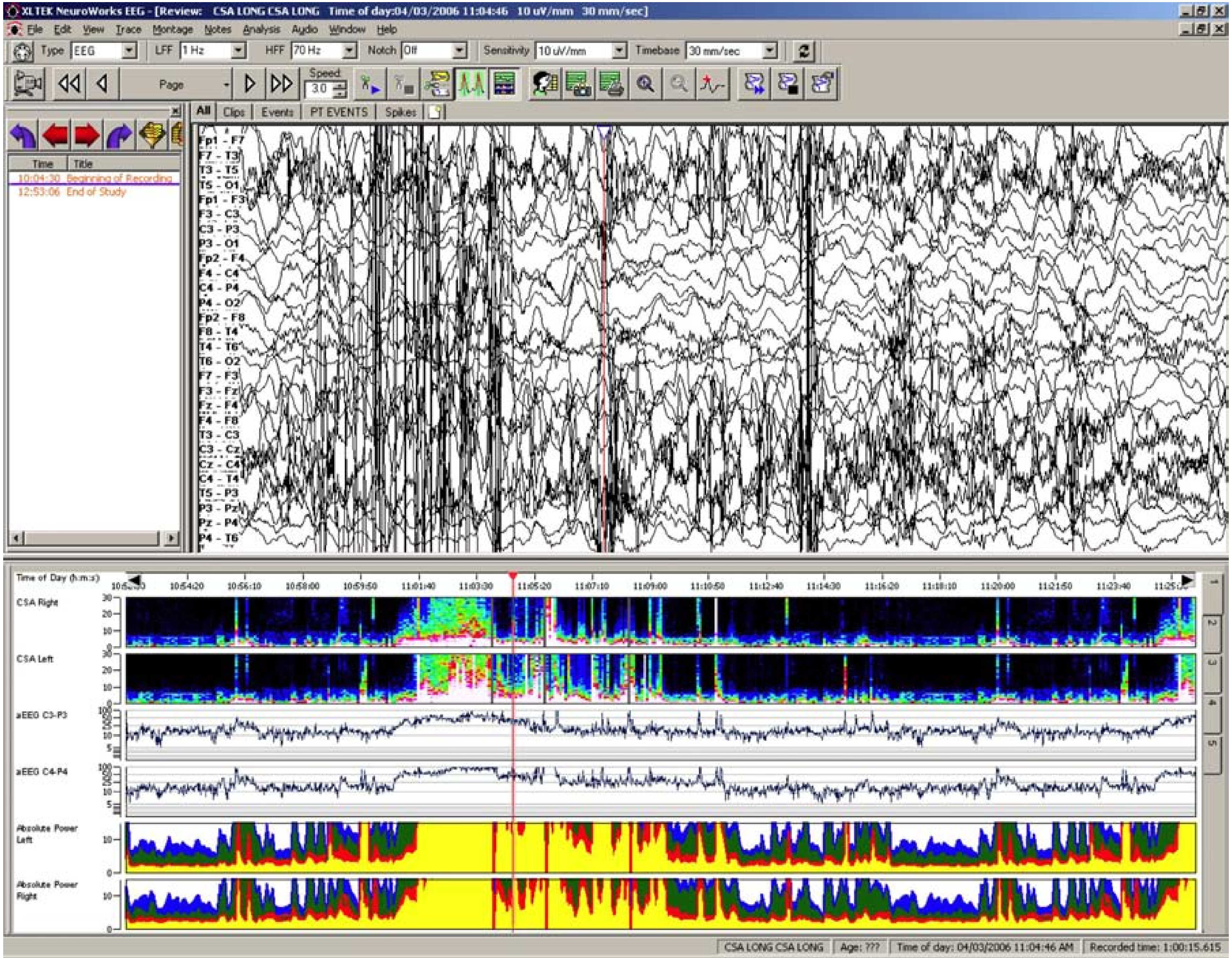
10:56:10
10:58:00
10:59:50
11:01:40
11:05:20
11:07:10
11:09:00
11:10:50
11:12:40
11:14:30
11:16:20
11:18:10
11:20:00
11:21:50
11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:04:06 AM
Recorded time: 0:59:36.215



XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:04:19 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG LFF 1 Hz HFF 70 Hz Notch Off Sensitivity 10 uV/mm Timebase 30 mm/sec
Page
Speed: 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
10:54:20 10:56:10 10:58:00 10:59:50 11:01:40 11:03:30 11:05:20 11:07:10 11:09:00 11:10:50 11:12:40 11:14:30 11:16:20 11:18:10 11:20:00 11:21:50 11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:04:19 AM
Recorded time: 0:59:49.345


XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:04:33 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG LFF 1 Hz HFF 70 Hz Notch Off Sensitivity 10 uV/mm Timebase 30 mm/sec
Page
Speed: 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
10:54:20
10:56:10
10:58:00
10:59:50
11:01:40
11:03:30
11:05:20
11:07:10
11:09:00
11:10:50
11:12:40
11:14:30
11:16:20
11:18:10
11:20:00
11:21:50
11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:04:33 AM
Recorded time: 1:00:02.475


XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:04:46 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG
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HFF 70 Hz
Notch Off
Sensitivity 10 uV/mm
Timebase 30 mm/sec
Page
Speed 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
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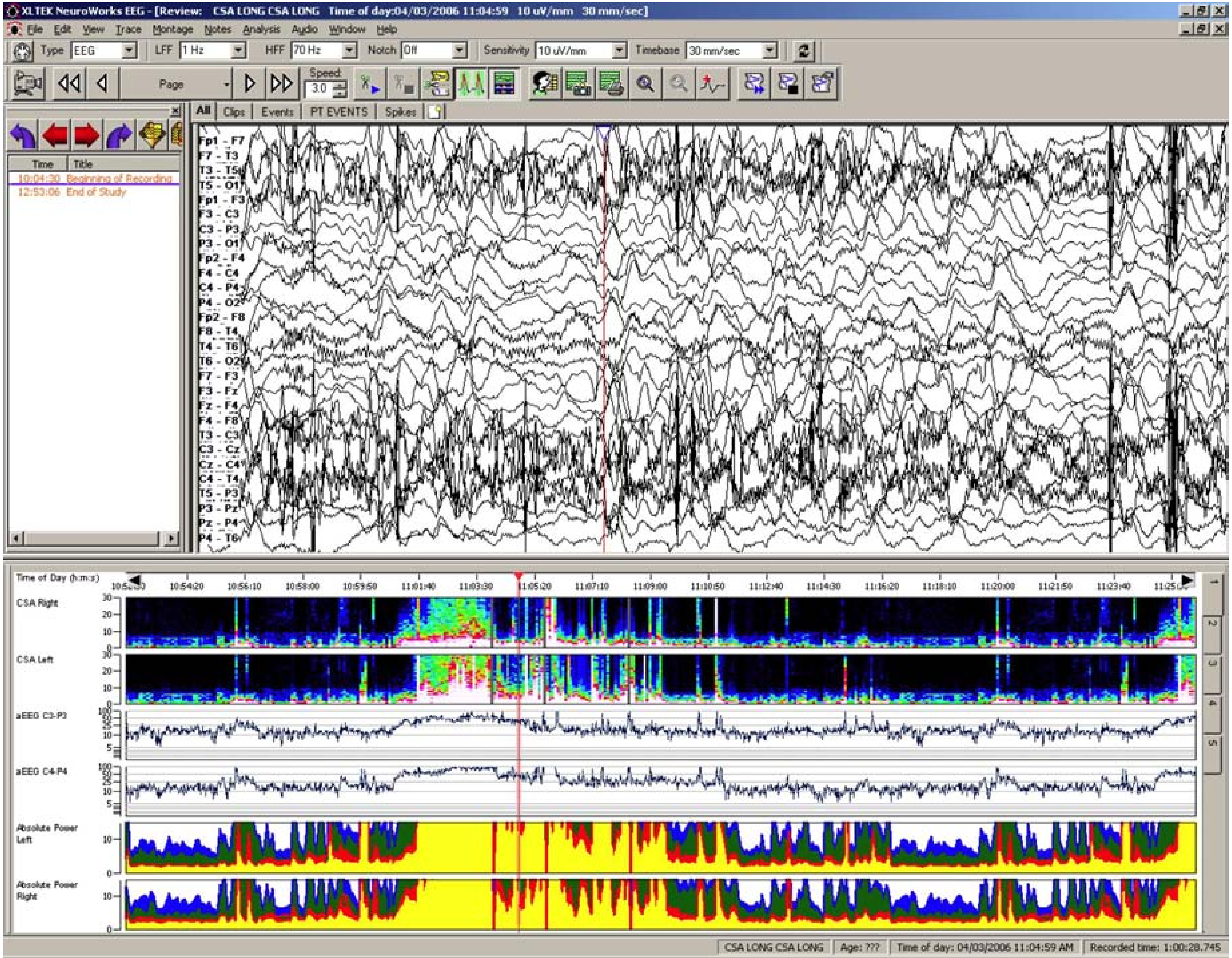
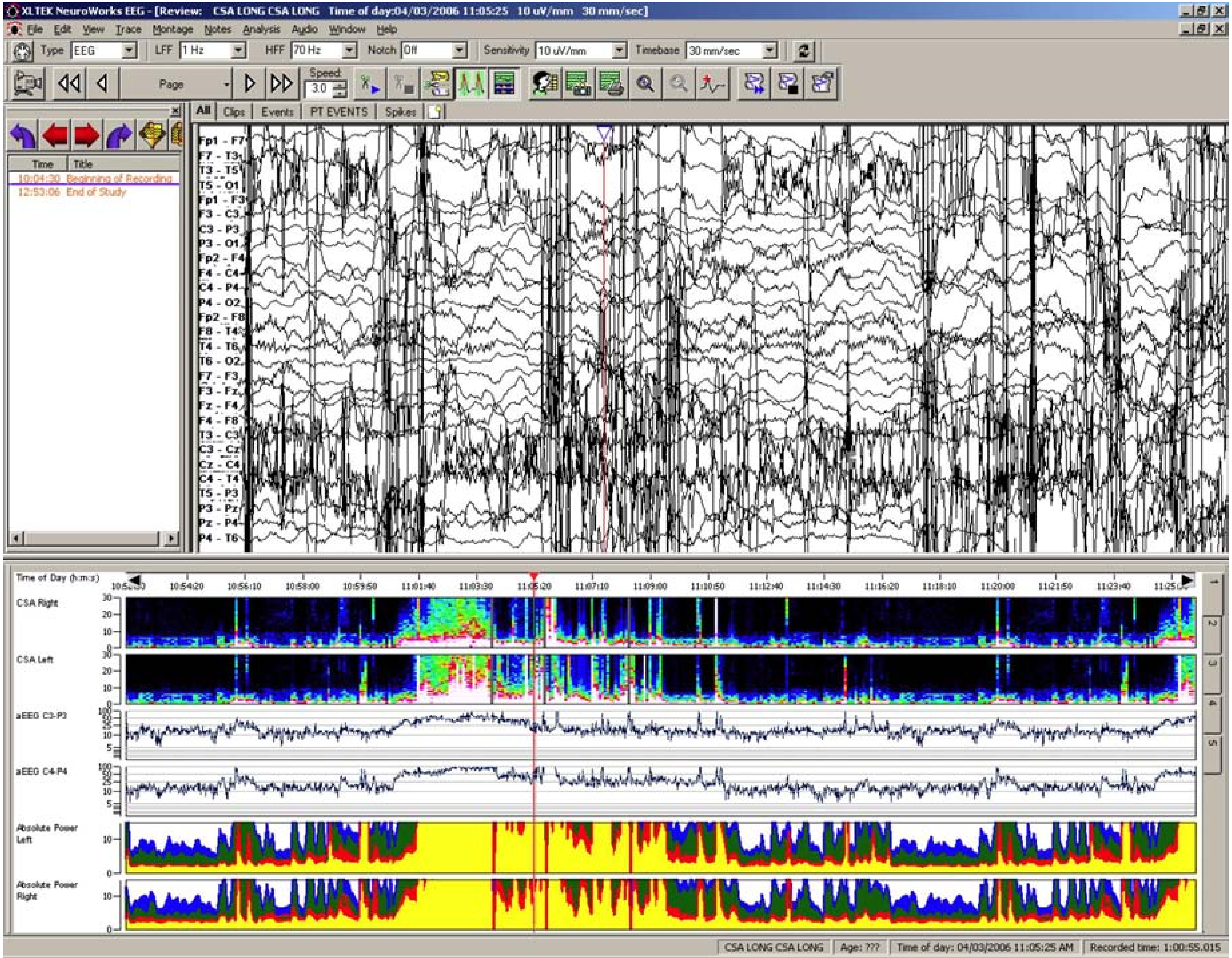
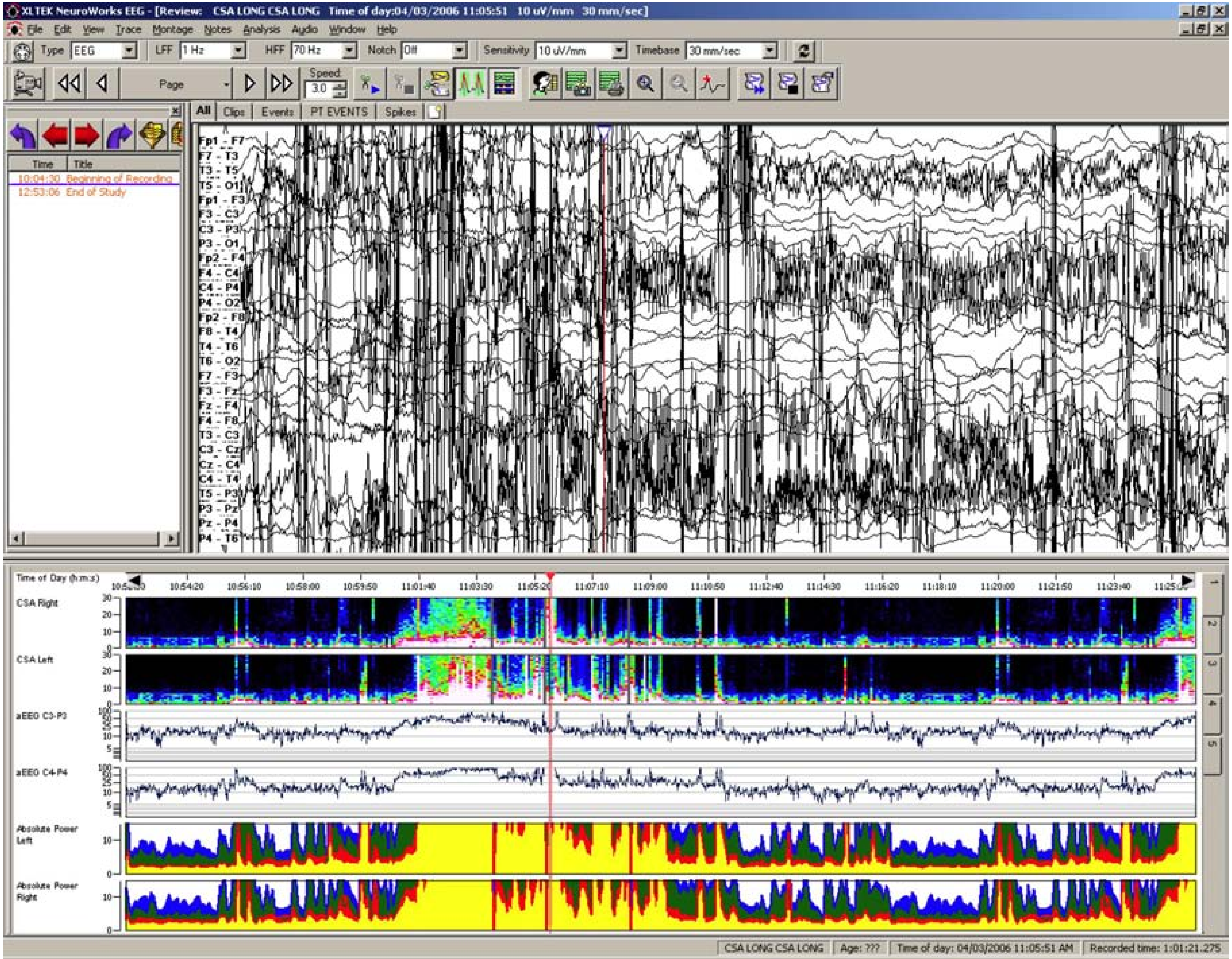
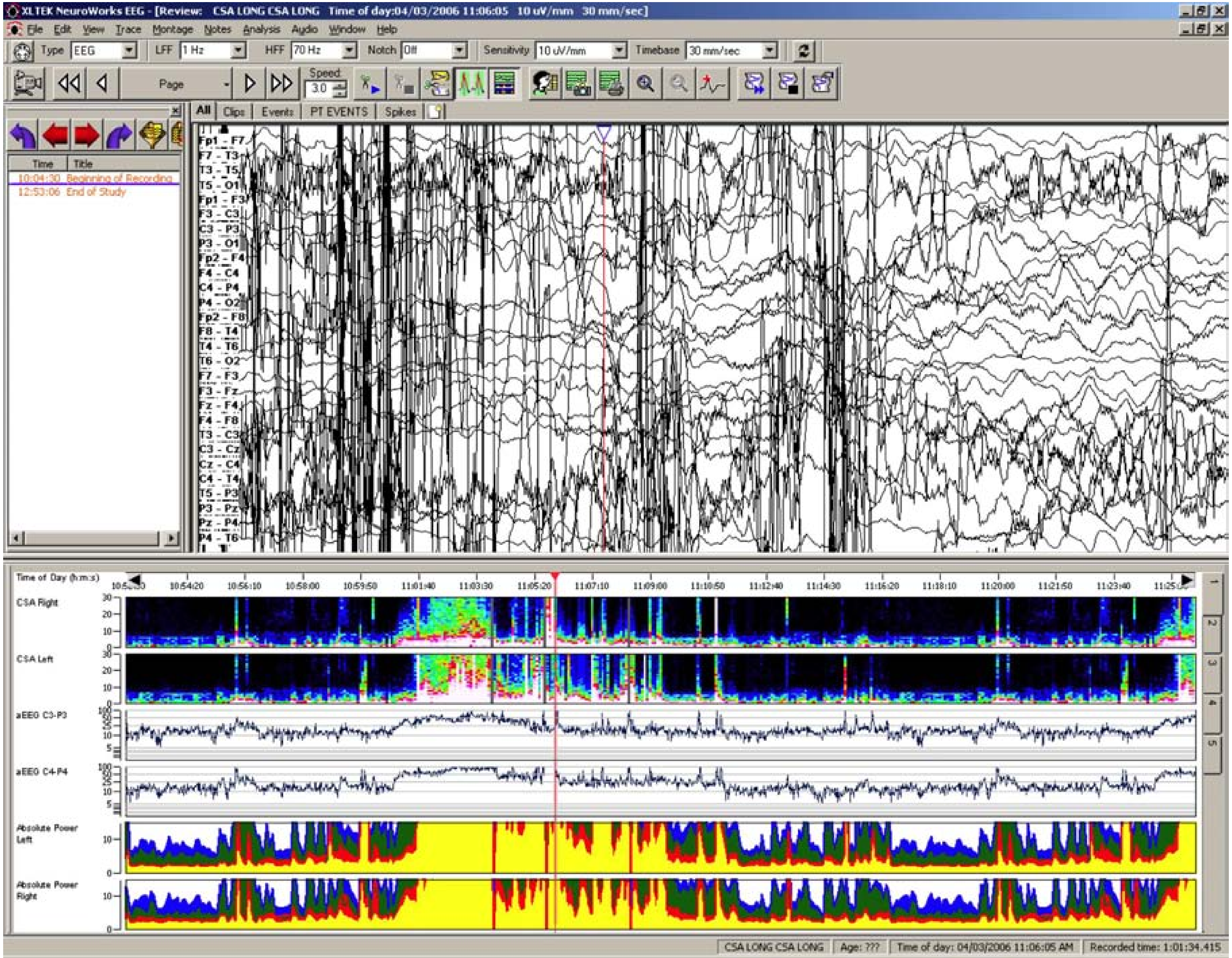
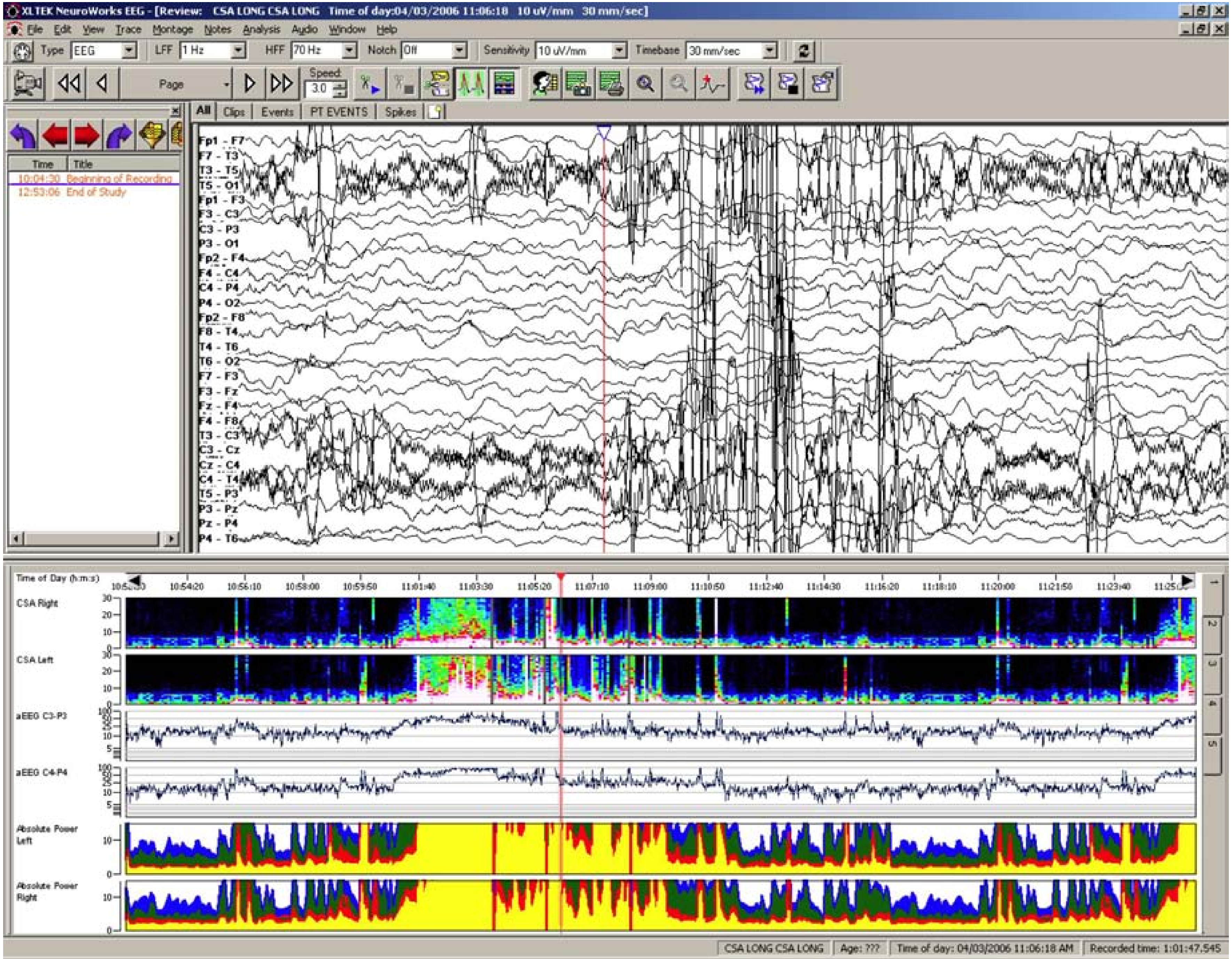
10:56:10
10:58:00
10:59:50
11:01:40
11:03:30
11:05:20
11:07:10
11:09:00
11:10:50
11:12:40
11:14:30
11:16:20
11:18:10
11:20:00
11:21:50
11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:04:46 AM
Recorded time: 1:00:15.615


XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:04:59 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG LFF 1 Hz HFF 70 Hz Notch Off Sensitivity 10 uV/mm Timebase 30 mm/sec
Page
Speed: 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
10:54:20 10:56:10 10:58:00 10:59:50 11:01:40 11:03:30 11:05:20 11:07:10 11:09:00 11:10:50 11:12:40 11:14:30 11:16:20 11:18:10 11:20:00 11:21:50 11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:04:59 AM
Recorded time: 1:00:28.745


XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:05:25 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG
LFF 1 Hz
HFF 70 Hz
Notch Off
Sensitivity 10 uV/mm
Timebase 30 mm/sec
Page
Speed: 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
10:54:20
10:56:10
10:58:00
10:59:50
11:01:40
11:03:30
11:07:10
11:09:00
11:10:50
11:12:40
11:14:30
11:16:20
11:18:10
11:20:00
11:21:50
11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:05:25 AM
Recorded time: 1:00:55.015


XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:05:51 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG LFF 1 Hz HFF 70 Hz Notch Off Sensitivity 10 uV/mm Timebase 30 mm/sec
Page Speed 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
10:54:20 10:56:10 10:58:00 10:59:50 11:01:40 11:03:30 11:07:10 11:09:00 11:10:50 11:12:40 11:14:30 11:16:20 11:18:10 11:20:00 11:21:50 11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:05:51 AM
Recorded time: 1:01:21.275


XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:06:05 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG
LFF 1 Hz
HFF 70 Hz
Notch Off
Sensitivity 10 uV/mm
Timebase 30 mm/sec
Page
Speed 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
10:54:20 10:56:10 10:58:00 10:59:50 11:01:40 11:03:30 11:05:20 11:07:10 11:09:00 11:10:50 11:12:40 11:14:30 11:16:20 11:18:10 11:20:00 11:21:50 11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:06:05 AM
Recorded time: 1:01:34.415


XLTEK NeuroWorks EEG - [Review: CSA LONG CSA LONG Time of day:04/03/2006 11:06:18 10 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG
LFF 1 Hz
HFF 70 Hz
Notch Off
Sensitivity 10 uV/mm
Timebase 30 mm/sec
Page
Speed 3.0
All
Clips
Events
PT EVENTS
Spikes
Time
Title
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12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
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11:01:40
11:03:30
11:05:20
11:07:10
11:09:00
11:10:50
11:12:40
11:14:30
11:16:20
11:18:10
11:20:00
11:21:50
11:23:40
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CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
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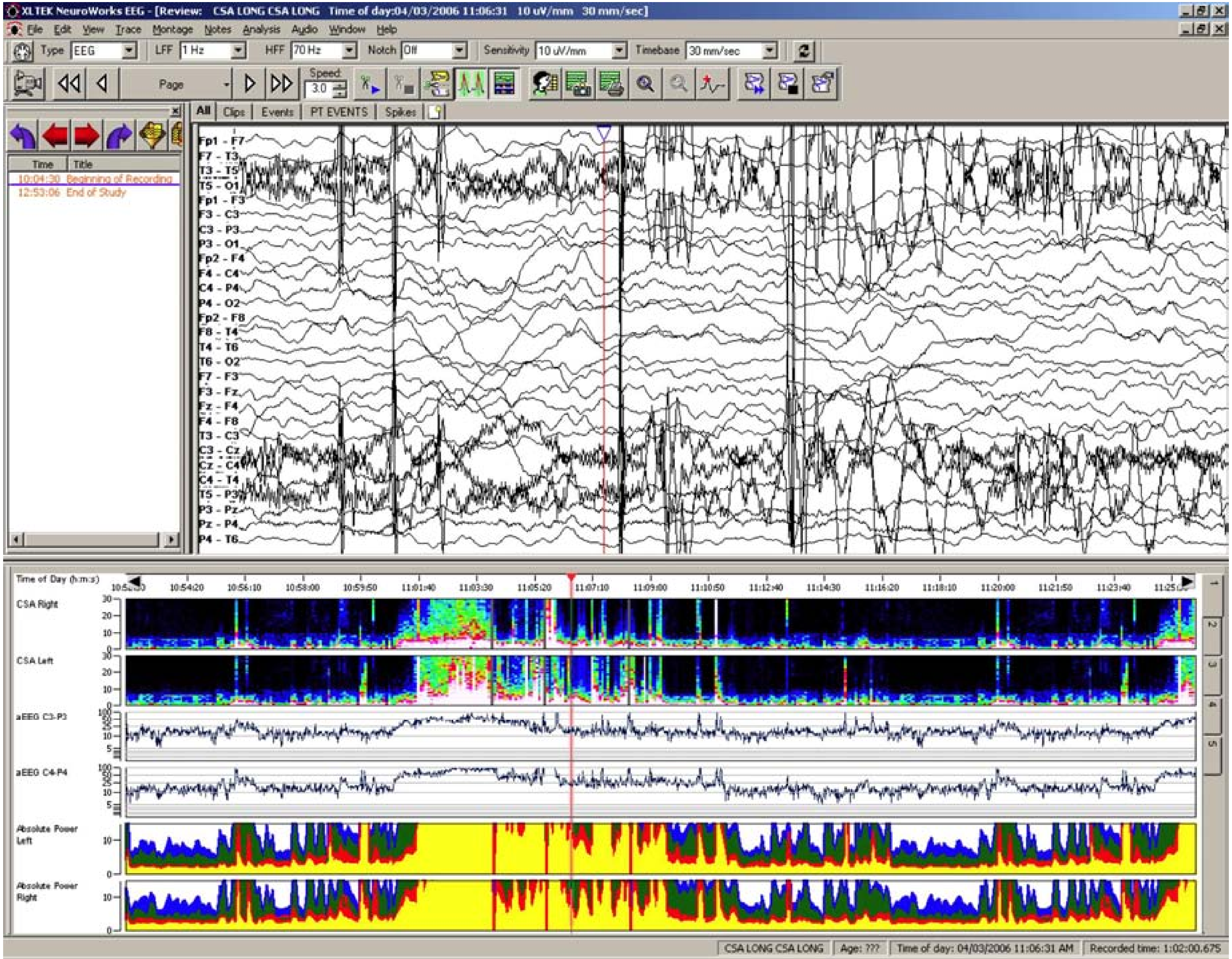
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All Clips Events PT EVENTS Spikes
Time Title
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12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
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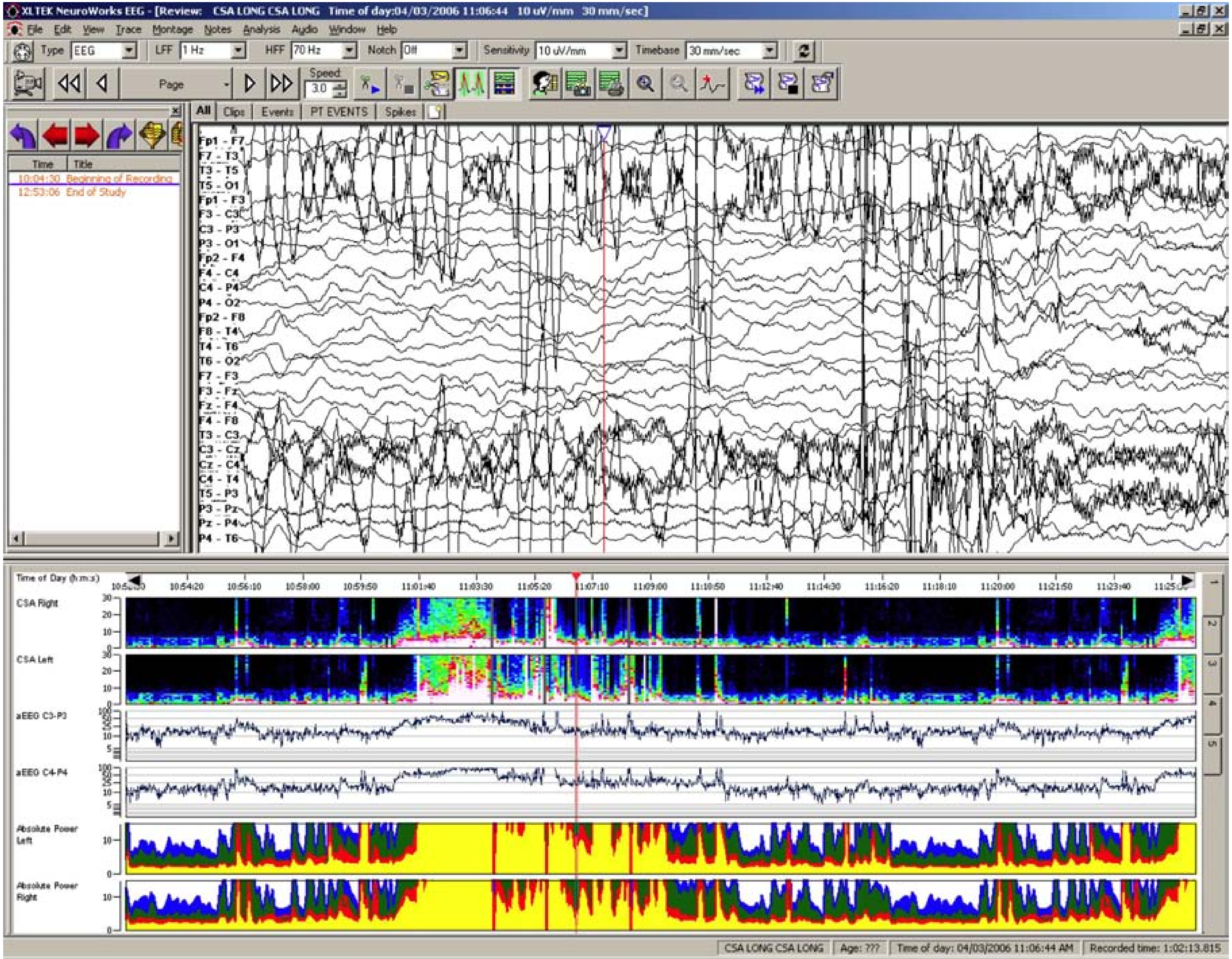

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Time Title
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12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
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10:56:10
10:58:00
10:59:50
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11:03:30
11:05:20
11:07:10
11:09:00
11:10:50
11:12:40
11:14:30
11:16:20
11:18:10
11:20:00
11:21:50
11:23:40
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
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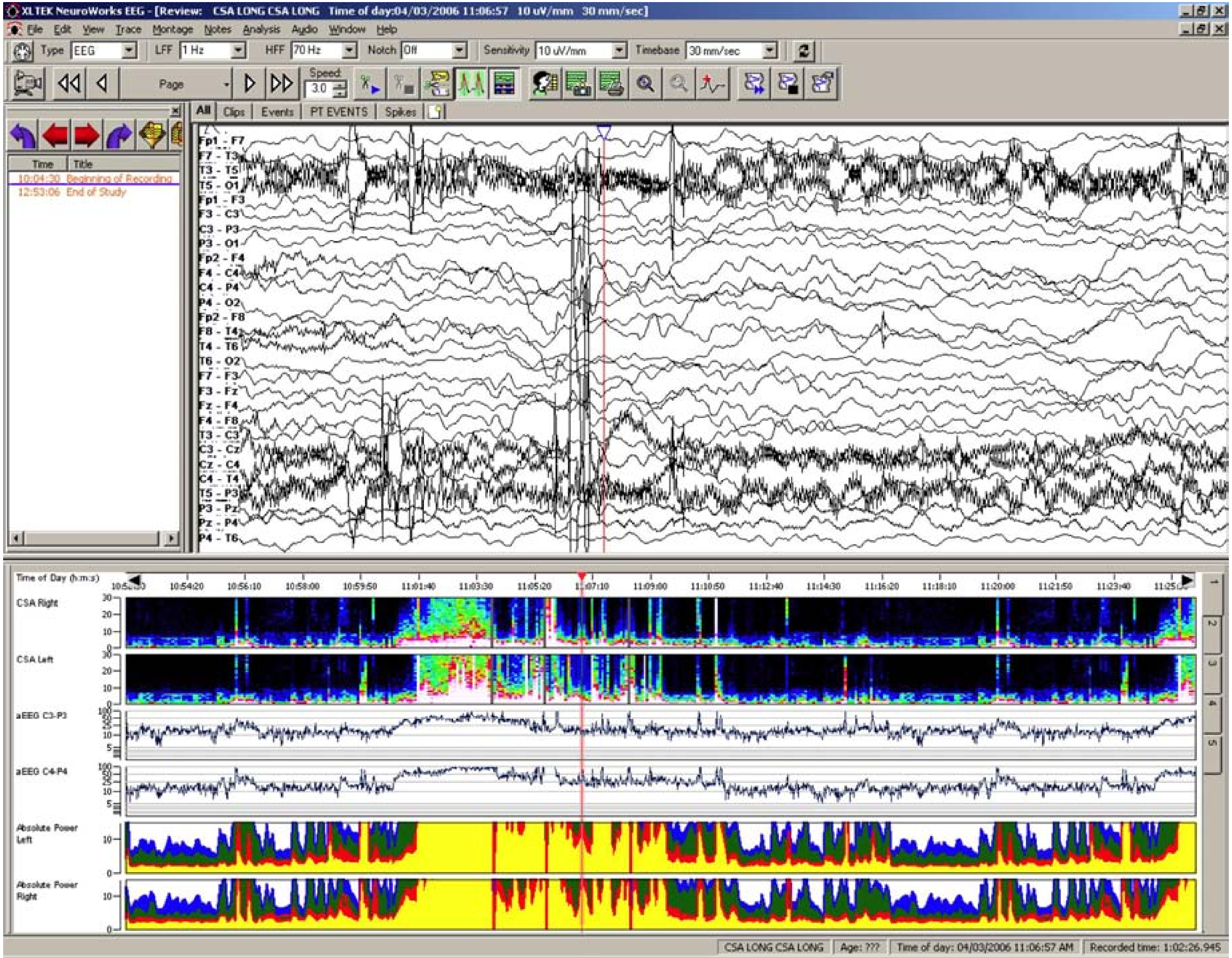
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Page
Speed: 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
F7 - F3
F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
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CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
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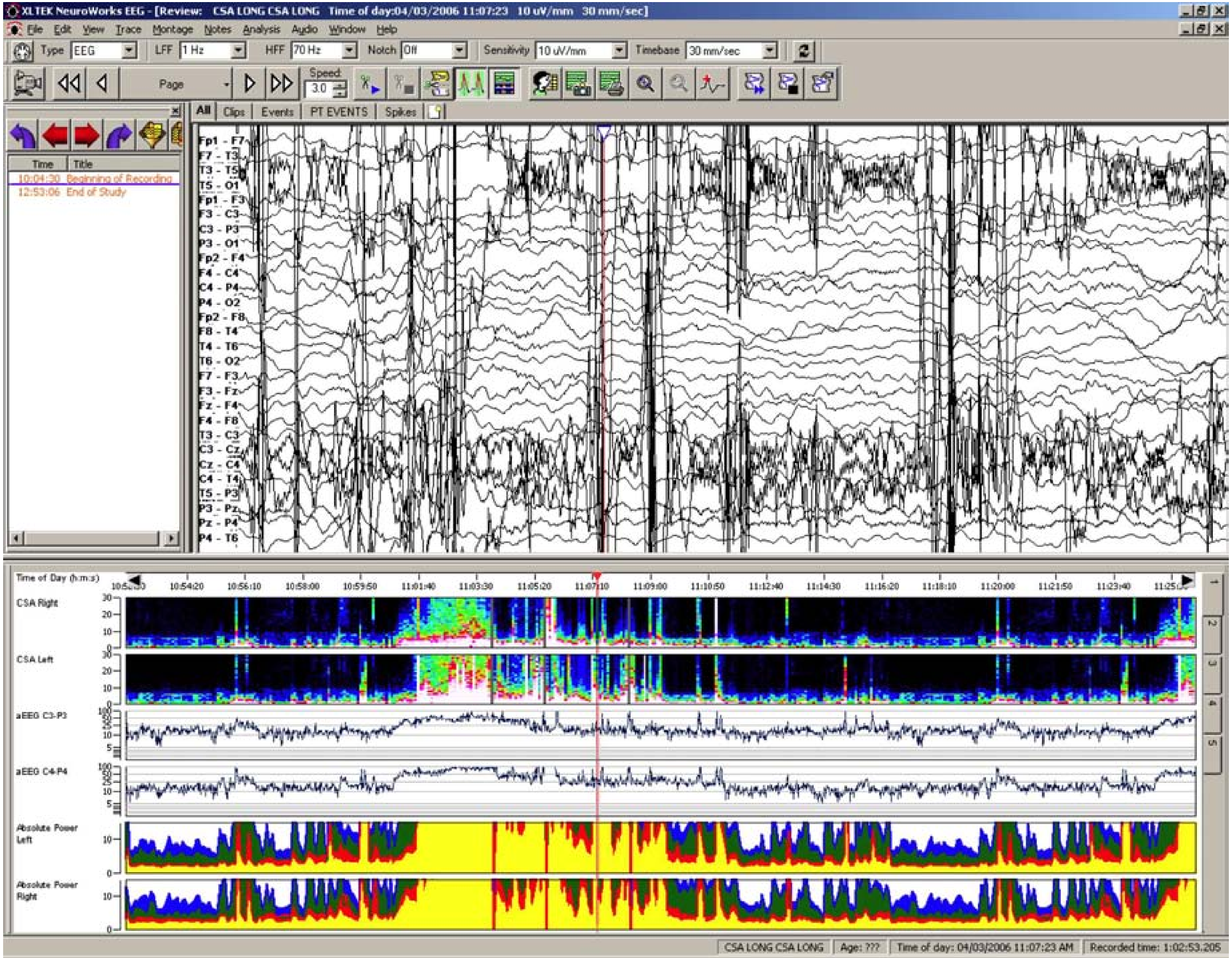
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Page Speed: 3.0
All Clips Events PT EVENTS Spikes
Time Title
10:04:30 Beginning of Recording
12:53:06 End of Study
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
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T6 - O2
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F3 - Fz
Fz - F4
F4 - F8
T3 - C3
C3 - Cz
Cz - C4
C4 - T4
T5 - P3
P3 - Pz
Pz - P4
P4 - T6
Time of Day (h:m:s)
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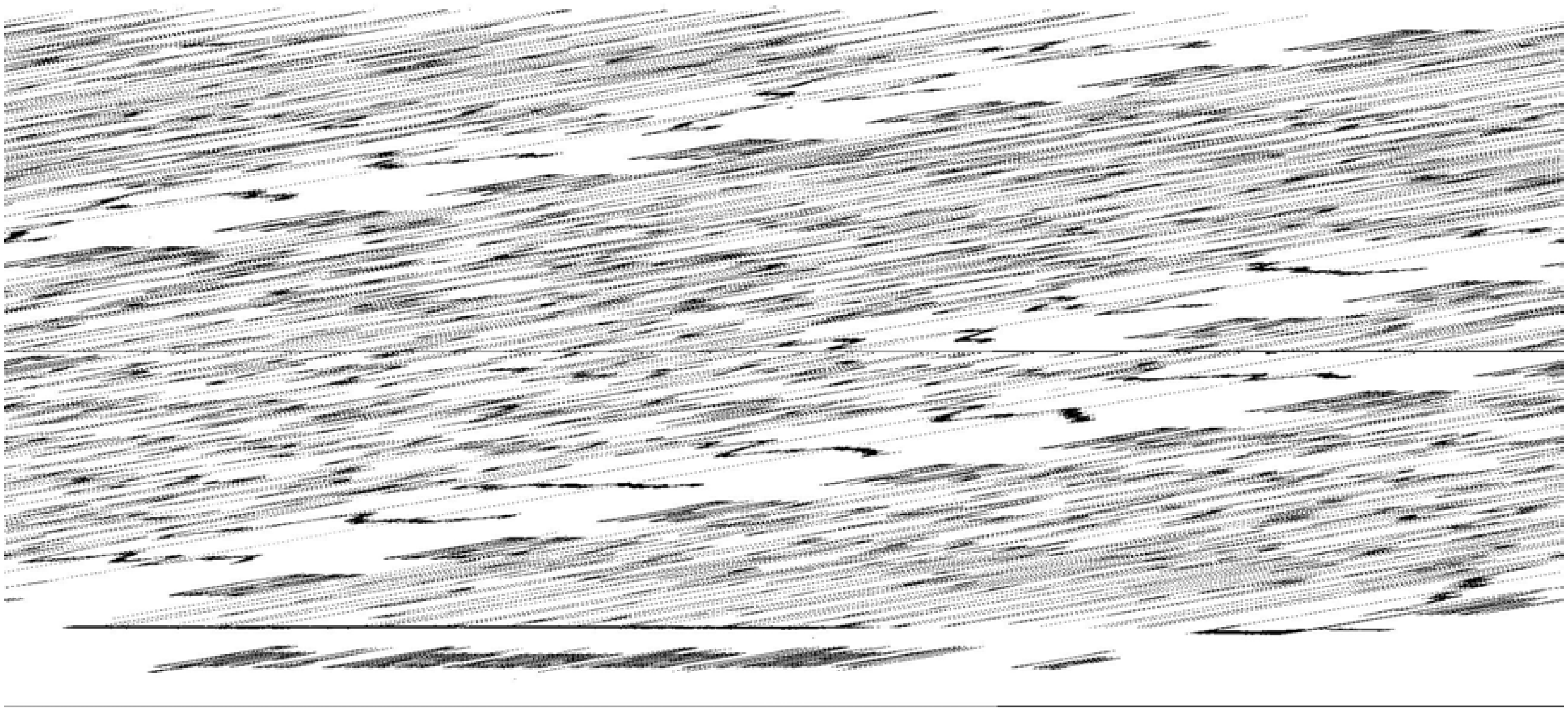
CSA Right
CSA Left
aEEG C3-P3
aEEG C4-P4
Absolute Power Left
Absolute Power Right
CSA LONG CSA LONG
Age: ???
Time of day: 04/03/2006 11:07:23 AM
Recorded time: 1:02:53.205

EEG stages of SE

1. Discrete seizures
2. Merging seizures
3. Continuous ictal activity
4. Continuous ictal activity with flat periods
5. Periodic epileptiform discharges

Treiman *et al* **Epilepsy Res** 1990;5:49-60

Discrete seizures



Labar and Barrera **J Clin Neurophysiol**

Merging seizures

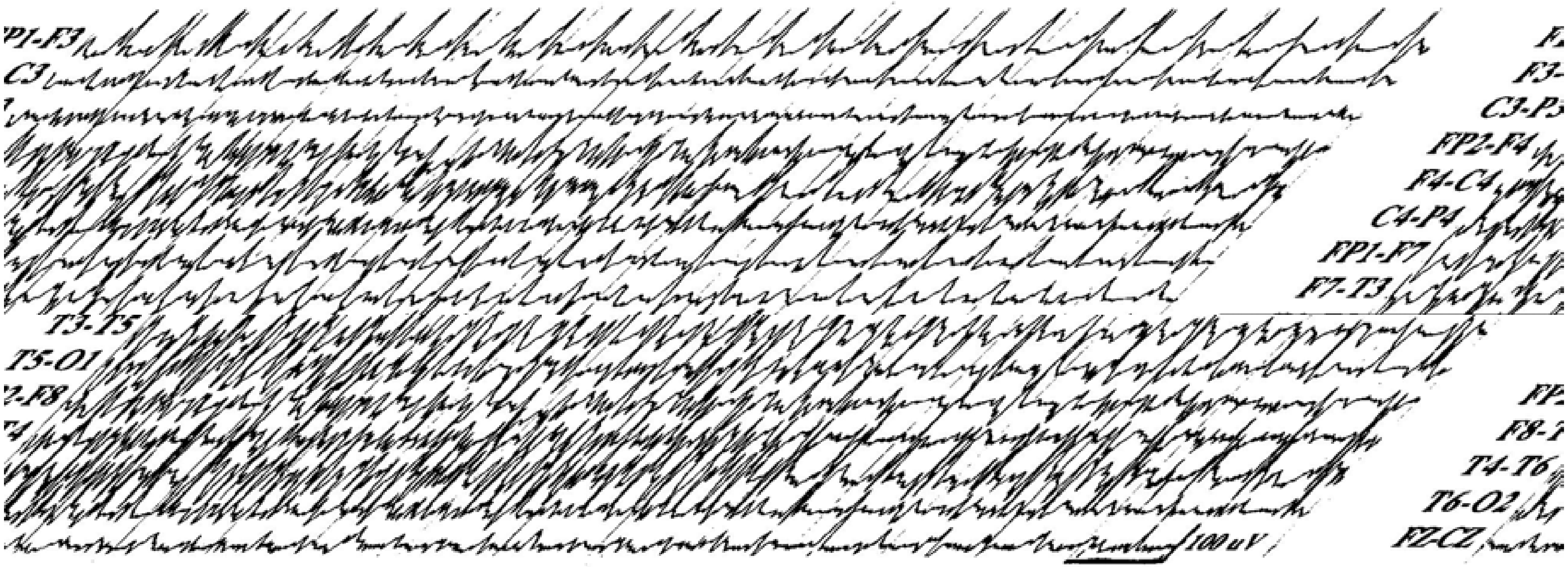


Figure 1B. Waxing and waning merging seizures (Pattern 2)(Patient #1)

Continuous/periodic ictal activity

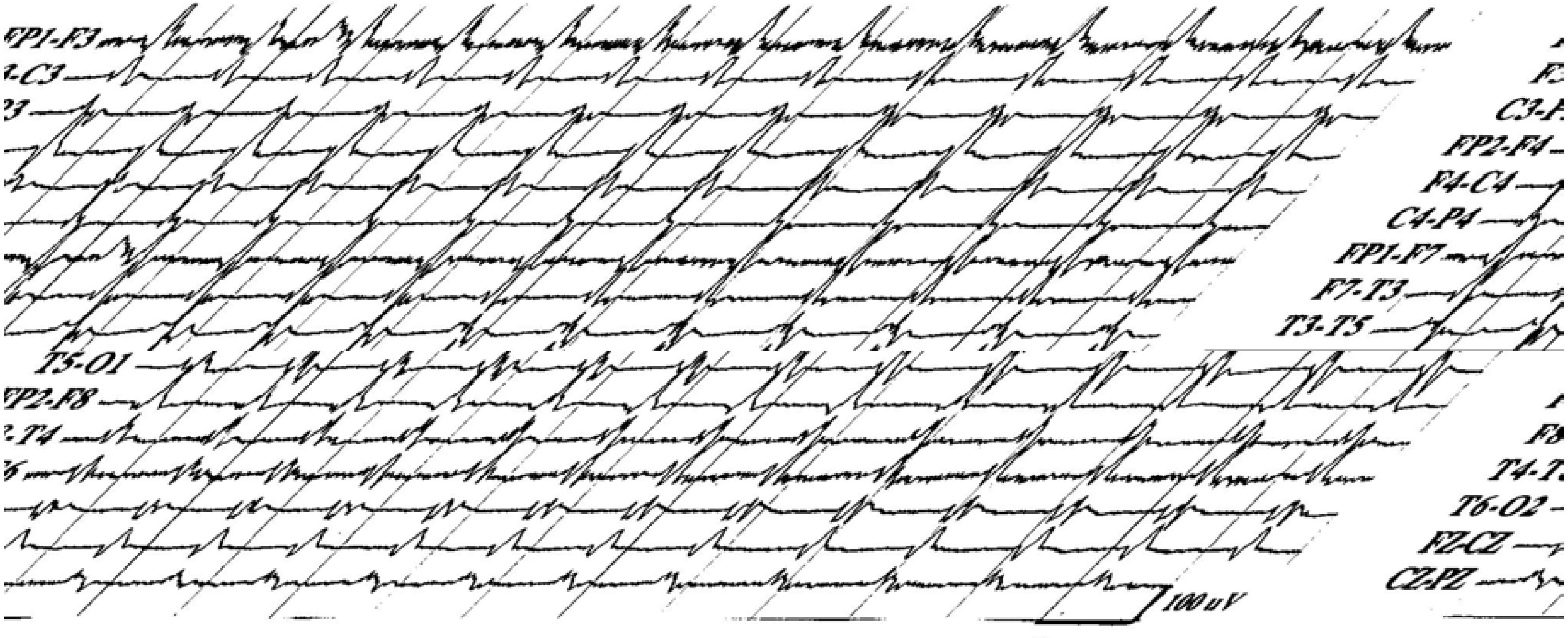
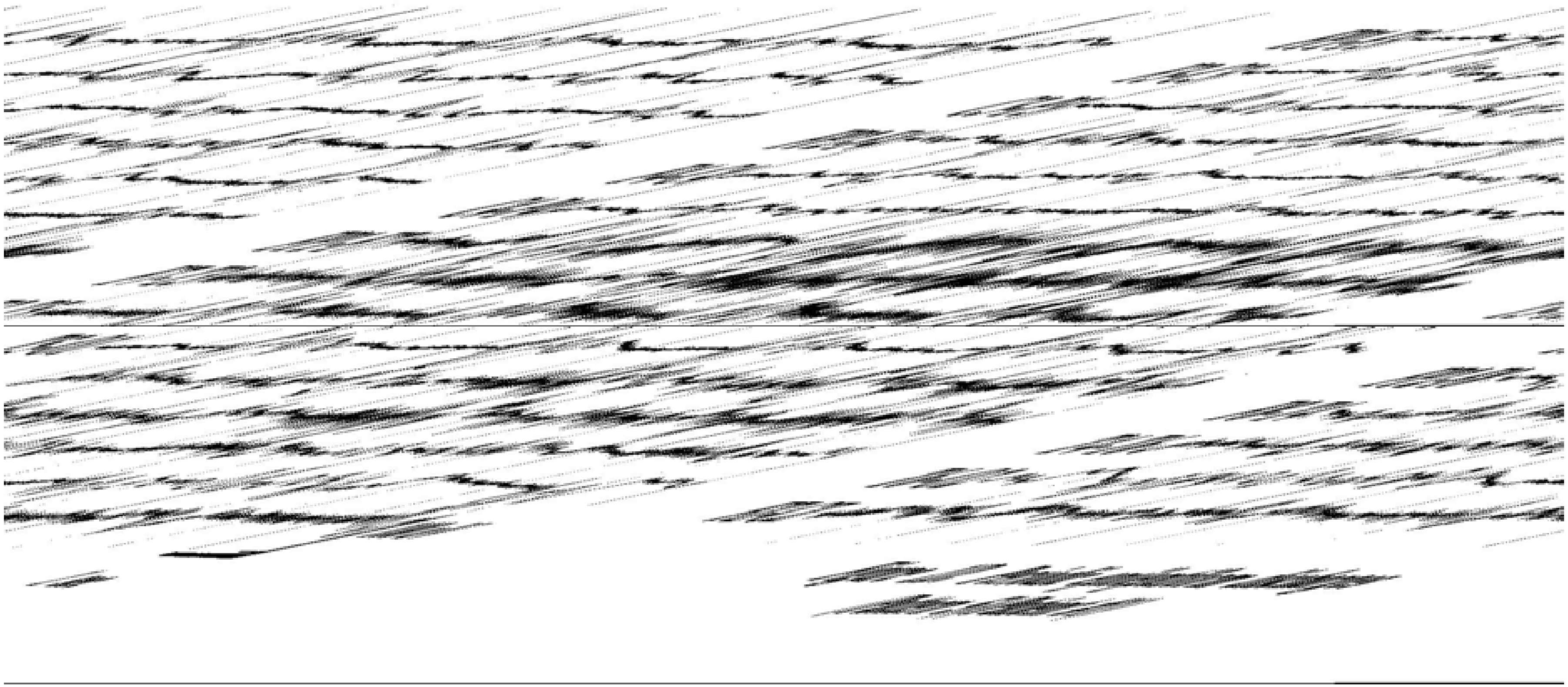


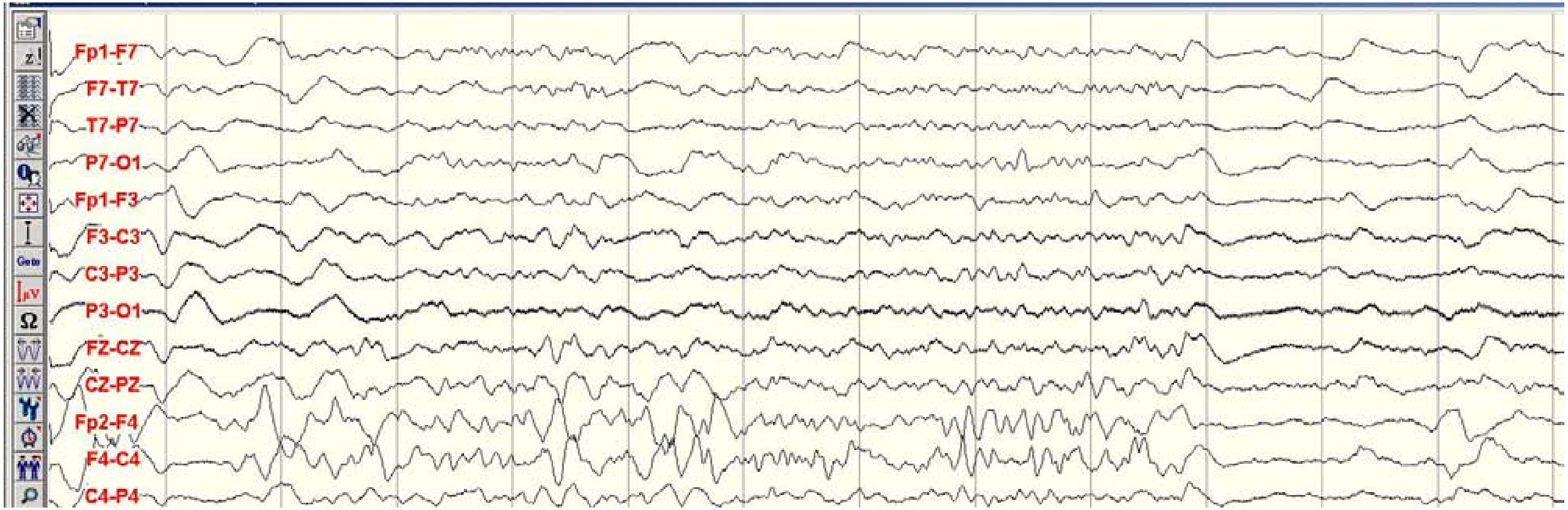
Figure 1C. Continuous ictal activity (Pattern 3)(Patient #1)

Periodic epileptiform activity



Is it or isn’t it?

- 47 year old man with $alpha_1$-antitrypsin deficiency
  - Underwent bilateral lung transplantation eight months before
  - Subsequently developed meningitis and brain abscesses with *Ochroconis galliparvum* (a dematiaceous fungus)
    - Initially responded to liposomal amphotericin B and voriconazole, but then relapsed
  - Now in coma without movements suggesting seizures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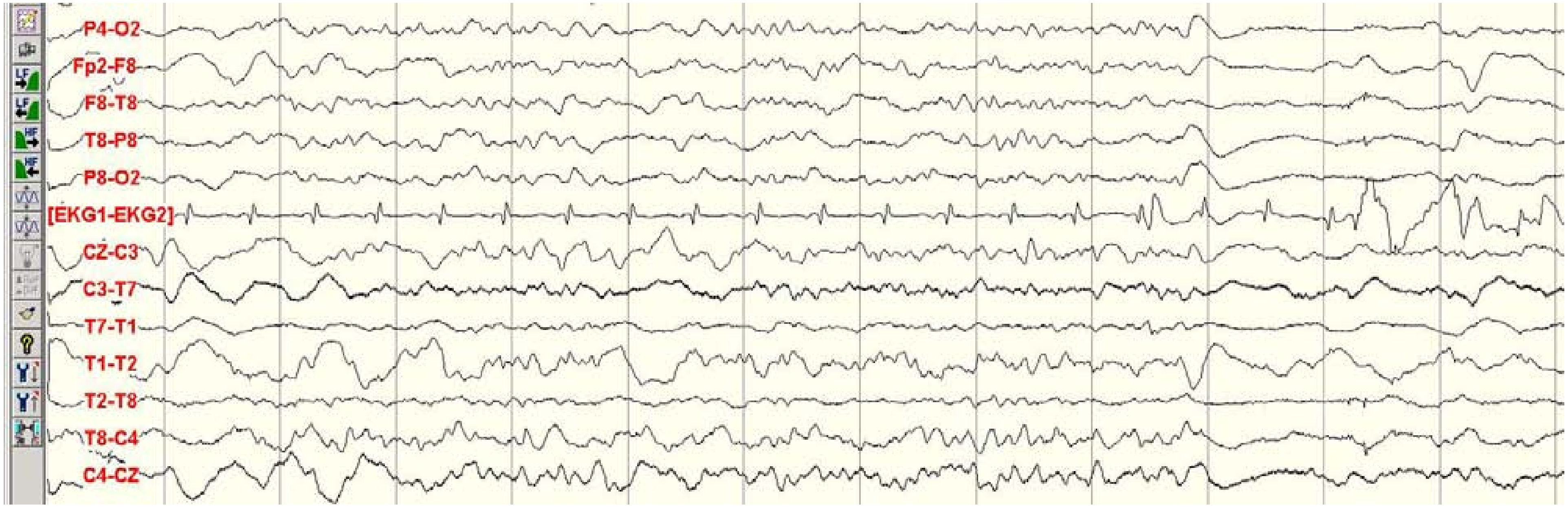
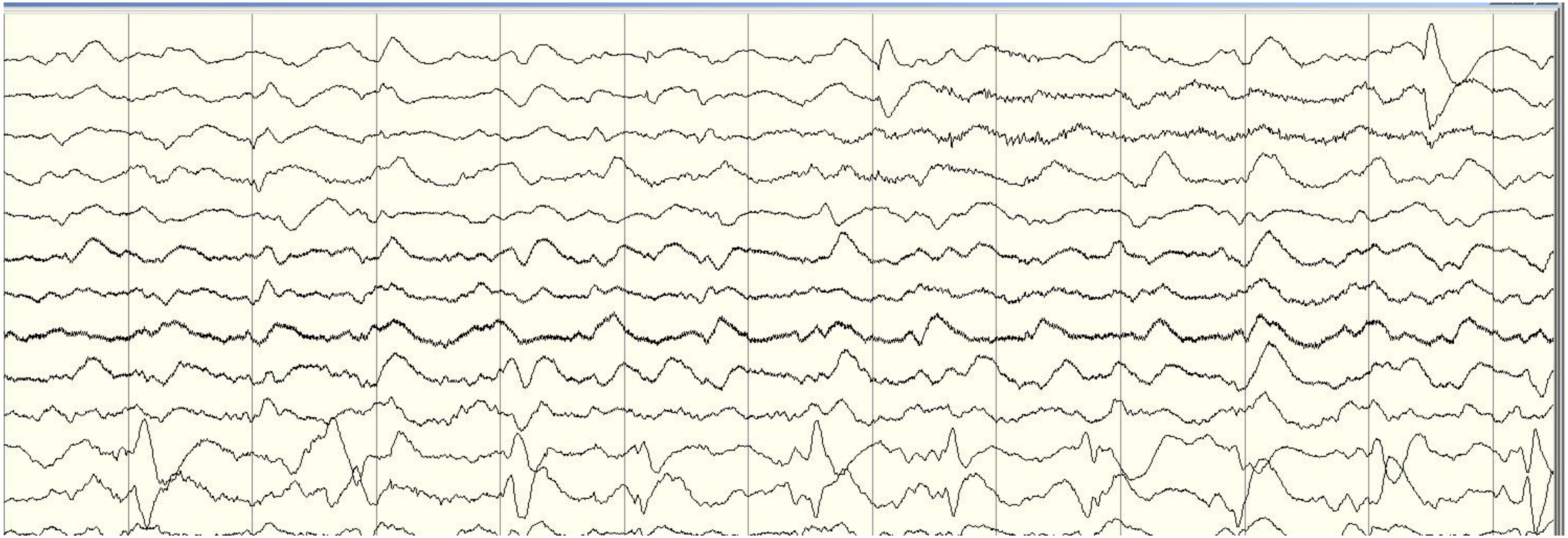
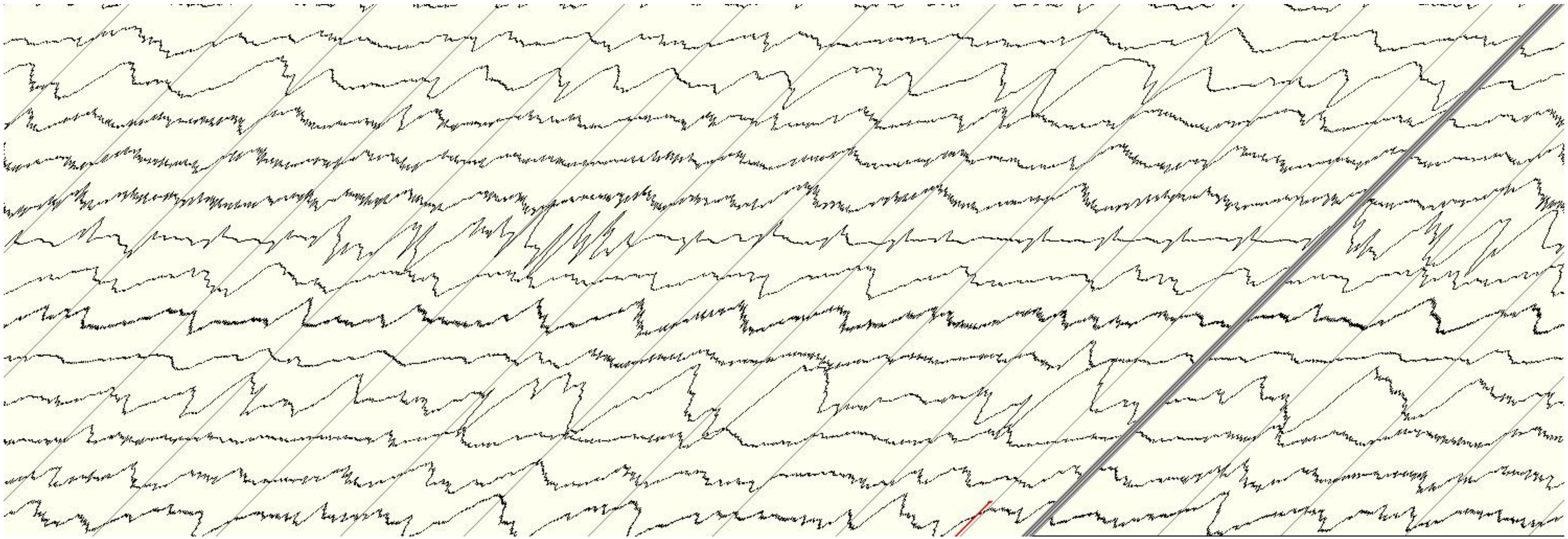
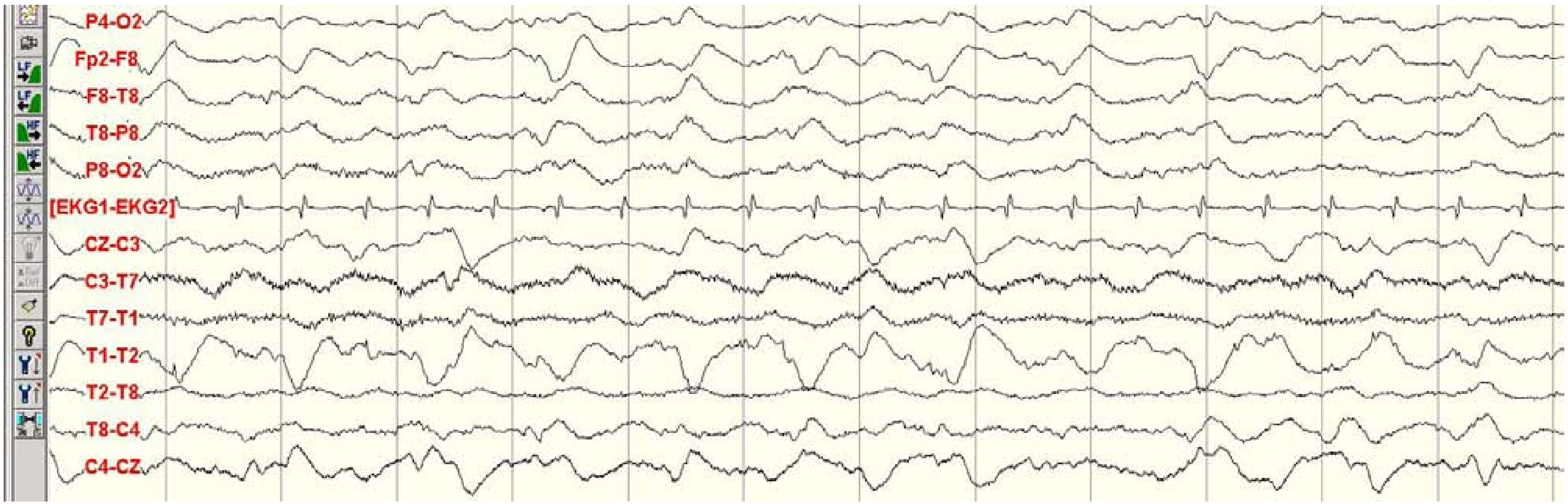
F7-T7
T7-P7
P7-O1
Fp1-F3
F3-C3
C3-P3
P3-O1
FZ-CZ
CZ-PZ
Fp2-F4
F4-C4
C4-P4


P4-O2
Fp2-F8
F8-T8
T8-P8
P8-O2
[EKG1-EKG2]
CZ-C3
C3-T7
T7-T1
T1-T2
T2-T8
T8-C4
C4-CZ


Fp1-F7
F7-T7
T7-P7
P7-O1
Fp1-F3
F3-C3
C3-P3
P3-O1
FZ-CZ
CZ-PZ
Fp2-F4
F4-C4
C4-P4


P4-O2
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F8-T8
T8-P8
P8-O2
[EKG1-EKG2]
CZ-C3
C3-T7
T7-T1
T1-T2
T2-T8
T8-C4
C4-CZ


Fp1-F7
F7-T7
T7-P7
P7-O1
Fp1-F3
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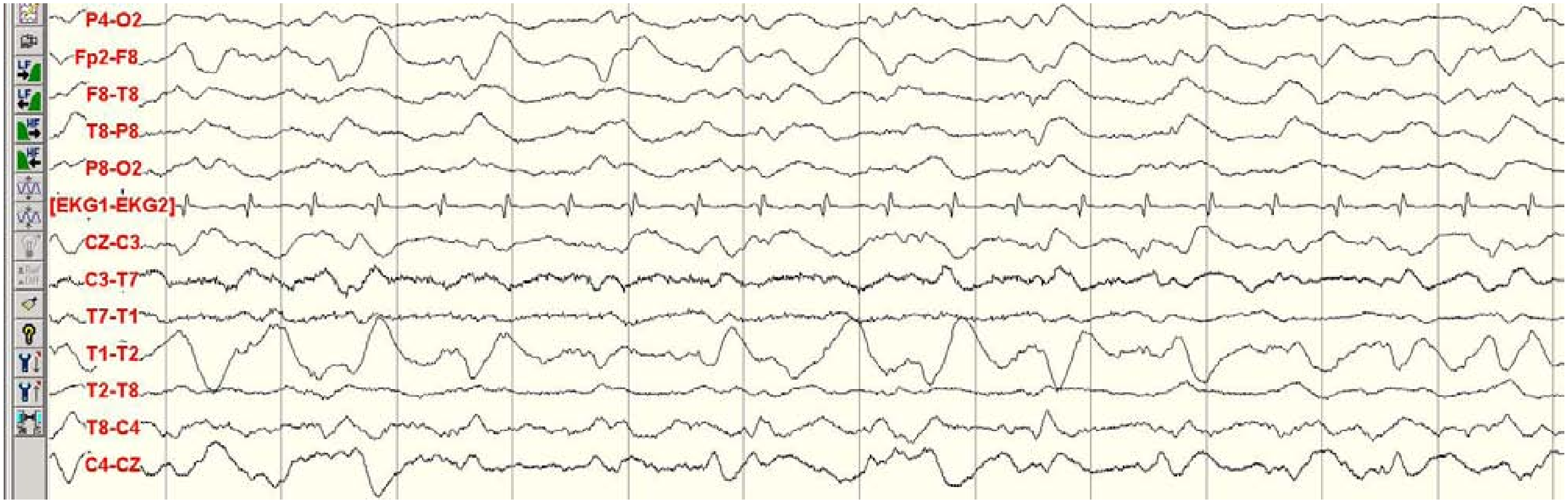
F4-C4
C4-P4


P4-O2
Fp2-F8
F8-T8
T8-P8
P8-O2
[EKG1-EKG2]
CZ-C3
C3-T7
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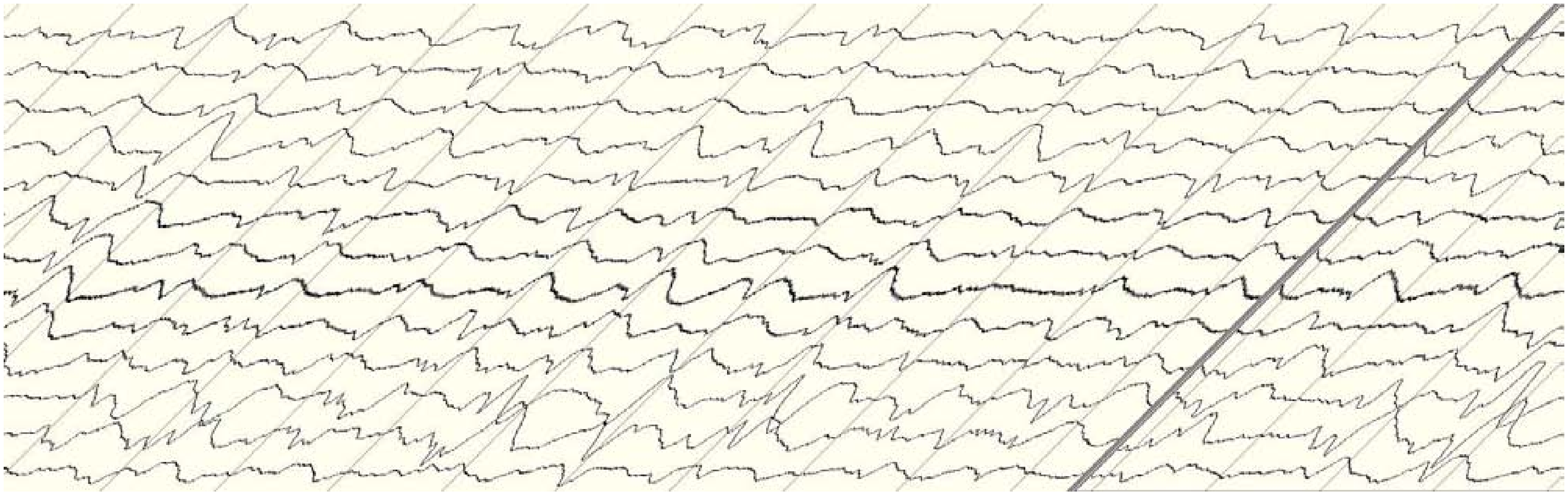
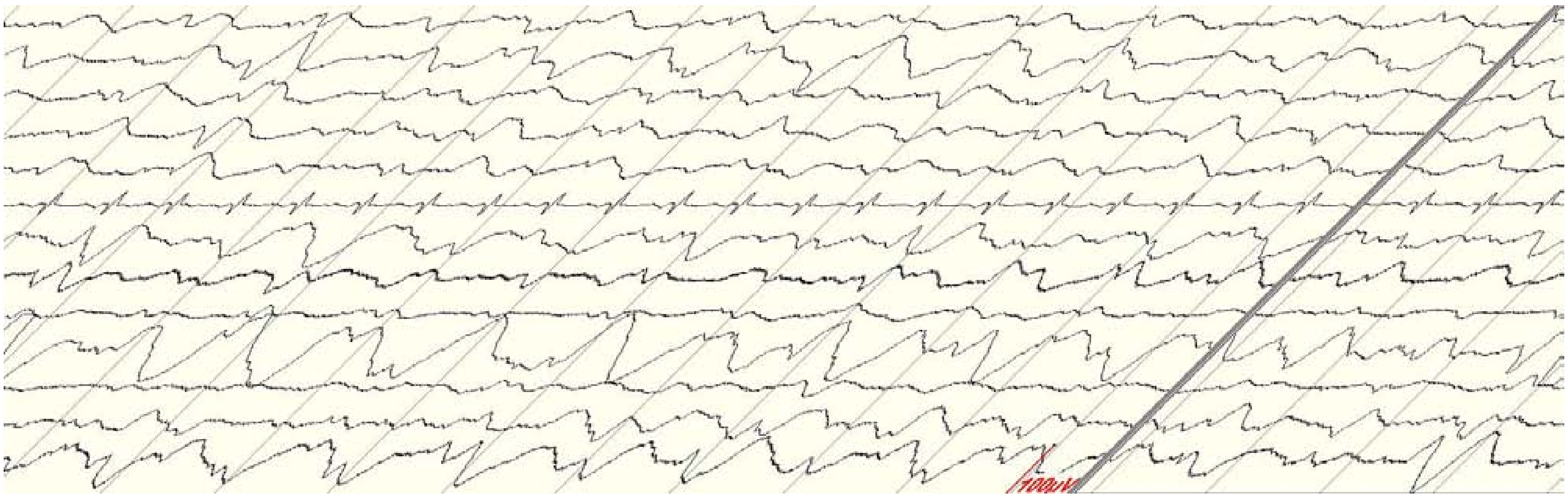
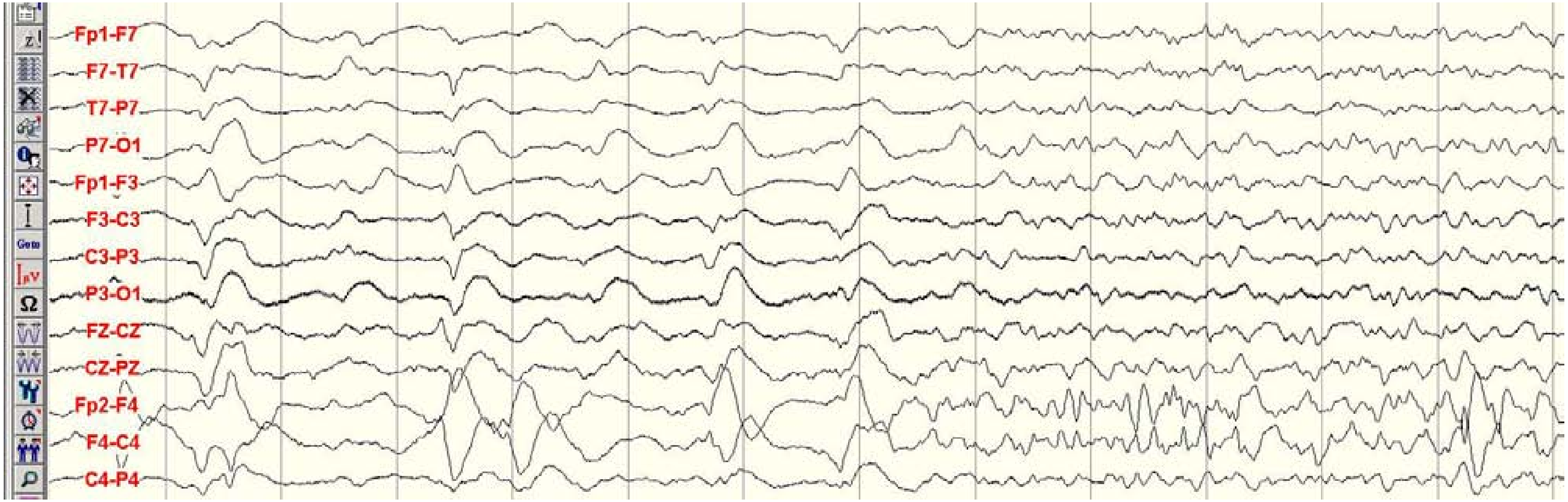
T8-C4
C4-CZ



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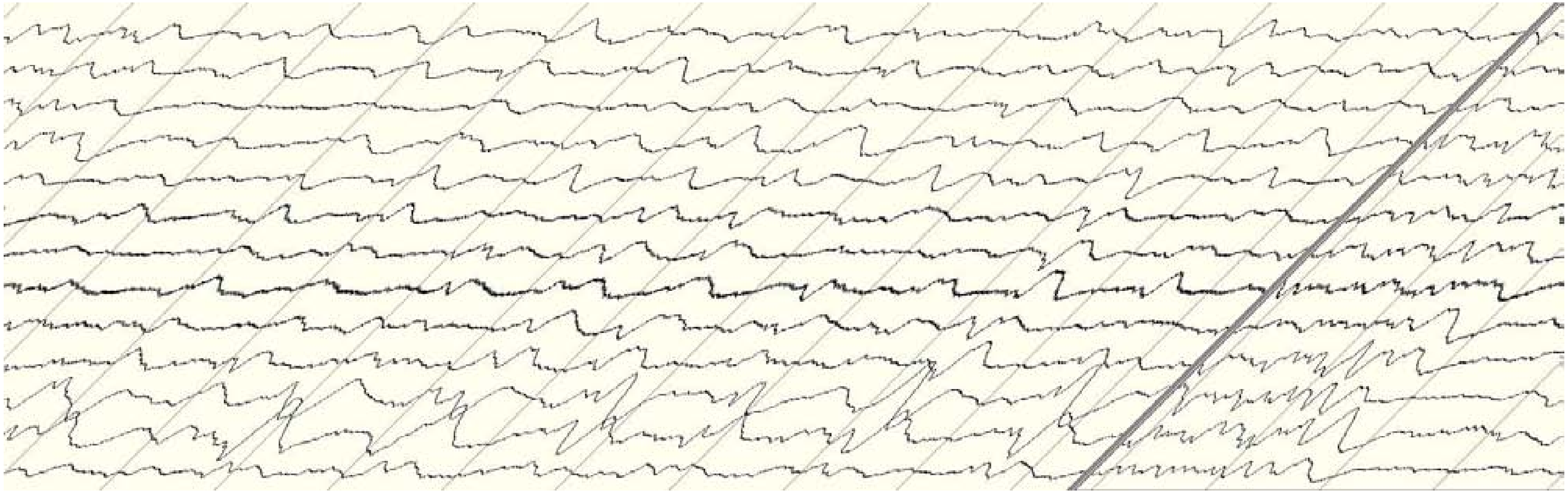
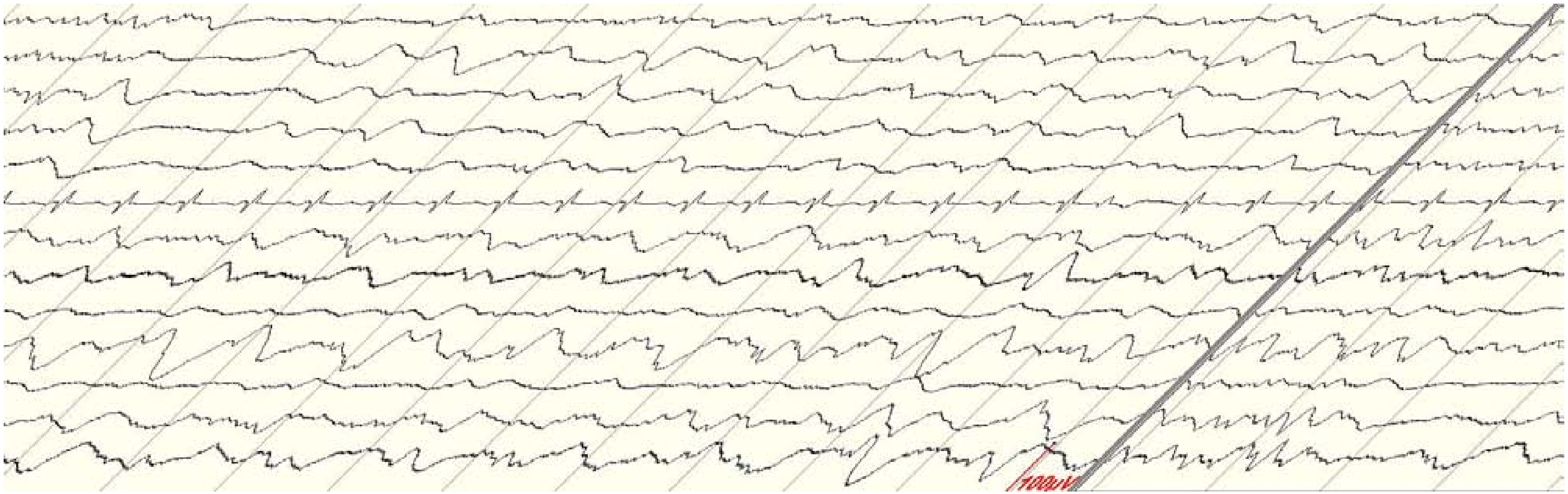
T7-P7
P7-O1
Fp1-F3
F3-C3
C3-P3
P3-O1
FZ-CZ
CZ-PZ
Fp2-F4
F4-C4
C4-P4


P4-O2
Fp2-F8
F8-T8
T8-P8
P8-O2
[EKG1-EKG2]
CZ-C3
C3-T7
T7-T1
T1-T2
T2-T8
T8-C4
C4-CZ




100uV

CME

Acute seizures after intracerebral hemorrhage

A factor in progressive midline shift and outcome

P.M. Vespa, MD; K. O'Phelan, MD; M. Shah, MD; J. Mirabelli, MD; S. Starkman, MD; C. Kidwell, MD; J. Saver, MD; M.R. Nuwer, MD; J.G. Frazee, MD; D.A. McArthur, PhD; and N.A. Martin, MD

Abstract—*Objective:* To determine whether early seizures that occur frequently after intracerebral hemorrhage (ICH) lead to increased brain edema as manifested by increased midline shift. *Methods:* A total of 109 patients with ischemic stroke (n = 46) and intraparenchymal hemorrhage (n = 63) prospectively underwent continuous EEG monitoring after admission. The incidence, timing, and factors associated with seizures were defined. Serial CT brain imaging was conducted at admission, 24 hours, and 48 to 72 hours after hemorrhage and assessed for hemorrhage volume and midline shift. Outcome at time of discharge was assessed using the Glasgow Outcome Scale score. *Results:* Electrographic seizures occurred in 18 of 63 (28%) patients with ICH, compared with 3 of 46 (6%) patients with ischemic stroke (OR = 5.7, 95% CI 1.4 to 26.5, $p < 0.004$) during the initial 72 hours after admission. Seizures were most often focal with secondary generalization. Seizures were more common in lobar hemorrhages but occurred in 21% of subcortical hemorrhages. Posthemorrhagic seizures were associated with neurologic worsening on the NIH Stroke Scale (14.8 vs 18.6, $p < 0.05$) and with an increase in midline shift (+ 2.7 mm vs −2.4 mm, $p < 0.03$). There was a trend toward increased poor outcome ($p < 0.06$) in patients with posthemorrhagic seizures. On multivariate analysis, age and initial NIH Stroke Scale score were independent predictors of outcome. *Conclusion:* Seizures occur commonly after ICH and may be nonconvulsive. Seizures are independently associated with increased midline shift after intraparenchymal hemorrhage.

NEUROLOGY 2003;60:1441–1446

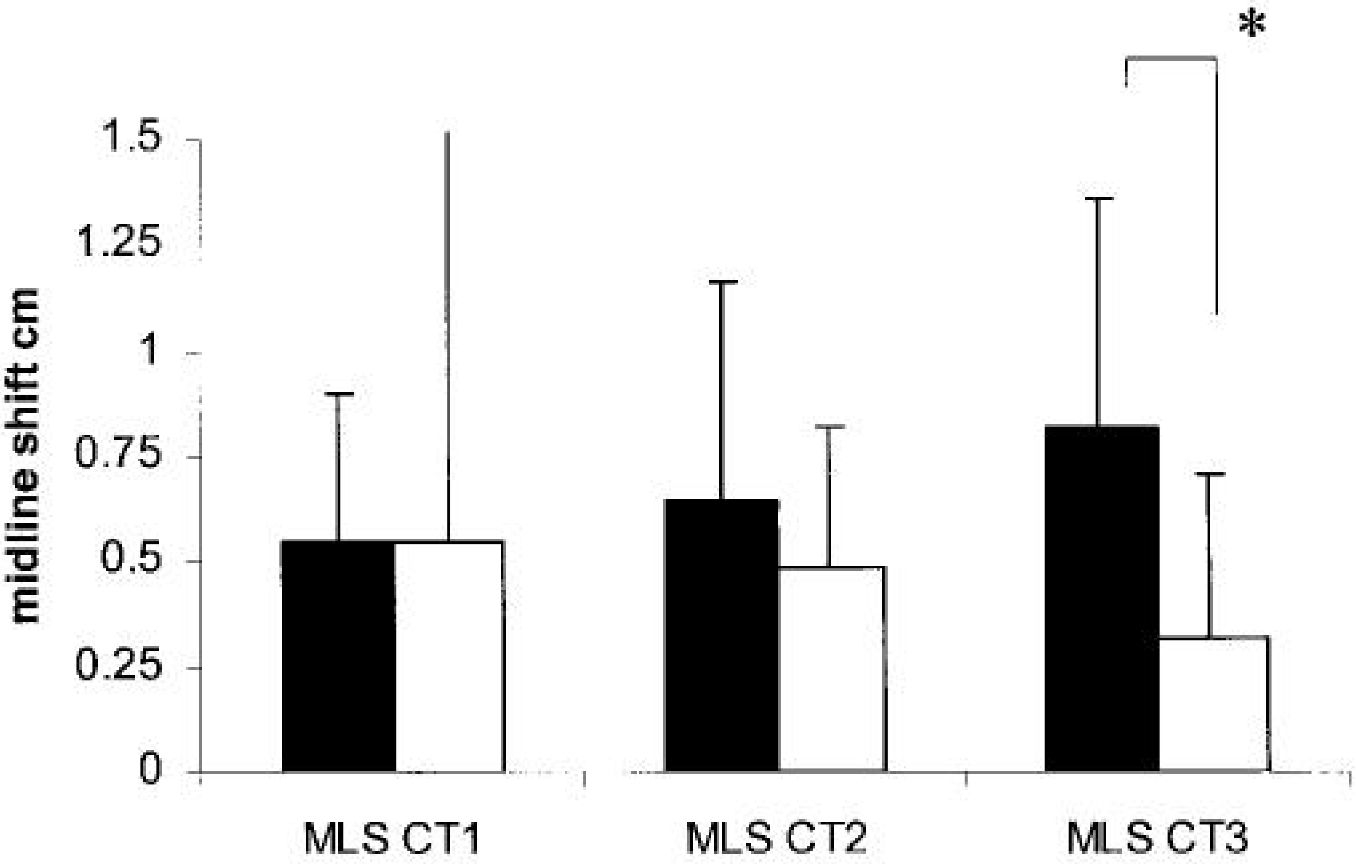


Figure 3. Comparison of the mean values of midline shift between patients with intracerebral hemorrhage with (black) and without (white) seizures on successive CT scans at 6, 24, and 48 to 72 hours.

Epilepsia, **(*):1–7, 2007
doi: 10.1111/j.1528-1167.2007.01327.x

FULL-LENGTH ORIGINAL RESEARCH

Cyclic electrographic seizures in critically ill patients

David E. Friedman, Catherine Schevon, Ronald G. Emerson, and Lawrence J. Hirsch

Comprehensive Epilepsy Center, Columbia University Medical Center, New York, New York, U.S.A.

SUMMARY

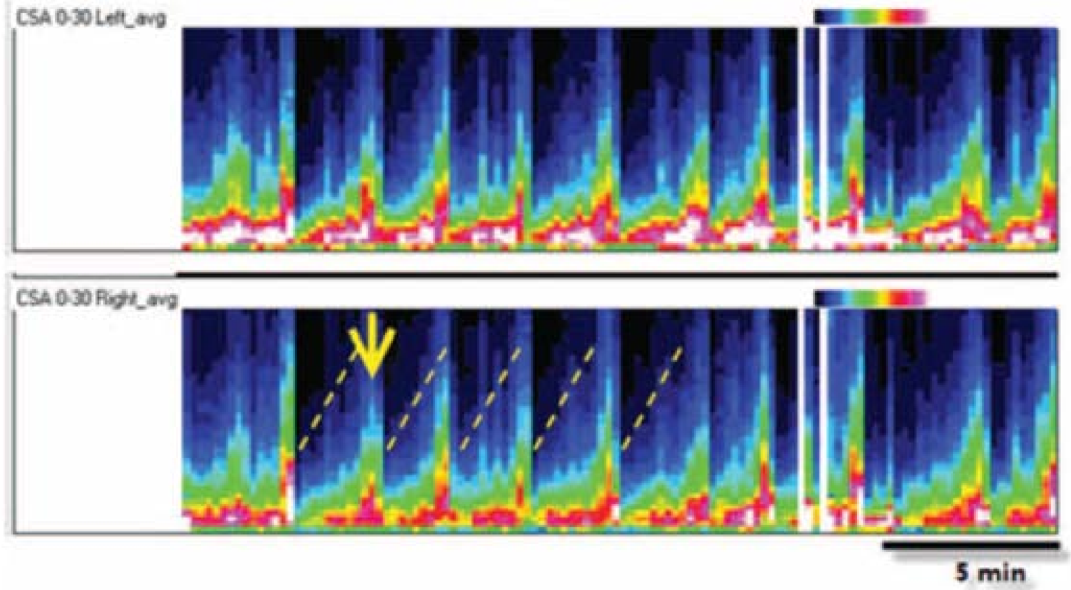
Purpose: Prolonged electroencephalographic monitoring has facilitated the detection of nonconvulsive seizures. Compressed displays of EEG frequency spectra (such as compressed spectral array, CSA) can facilitate interpretation of continuous EEG by allowing the reader to observe on a single screen patterns evolving over many minutes or hours.

Methods: Patients were identified retrospectively over a 4-year period as displaying a cycling pattern of seizures on CSA.

Results: We describe a pattern of seizures recurring in a cyclic fashion in a series of 13 critically ill patients of all ages. Several patients had a gradual buildup of EEG power prior to each seizure.

Conclusion: We believe that while not rare, this pattern is difficult to recognize on standard EEG recording but it is readily apparent on CSA. The underlying pathophysiology of cyclic seizures is not known, but we speculate that cyclic seizures represent a form of status epilepticus in which the usual seizure terminating factors are present and transiently effective, but are inadequate to prevent resumption of the seizure activity. Studying these patients may provide insight into the pathophysiology of seizure initiation and cessation.

KEY WORDS: Cyclic seizures, Compressed spectral array, Continuous EEG.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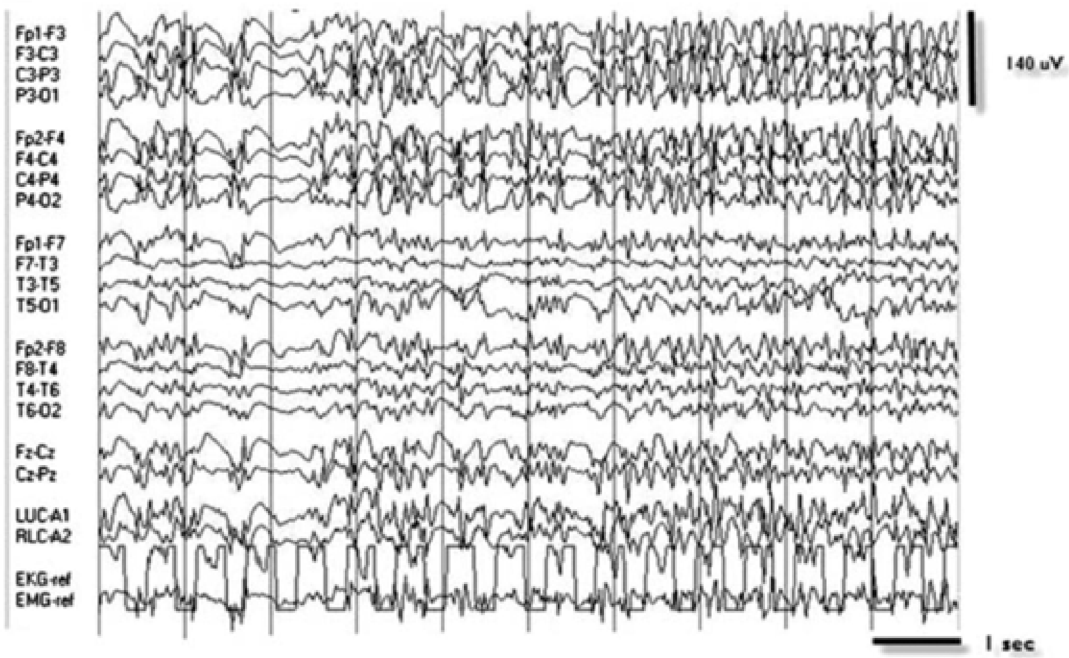
CSA 0-30 Right_avg
5 min

B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C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
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F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
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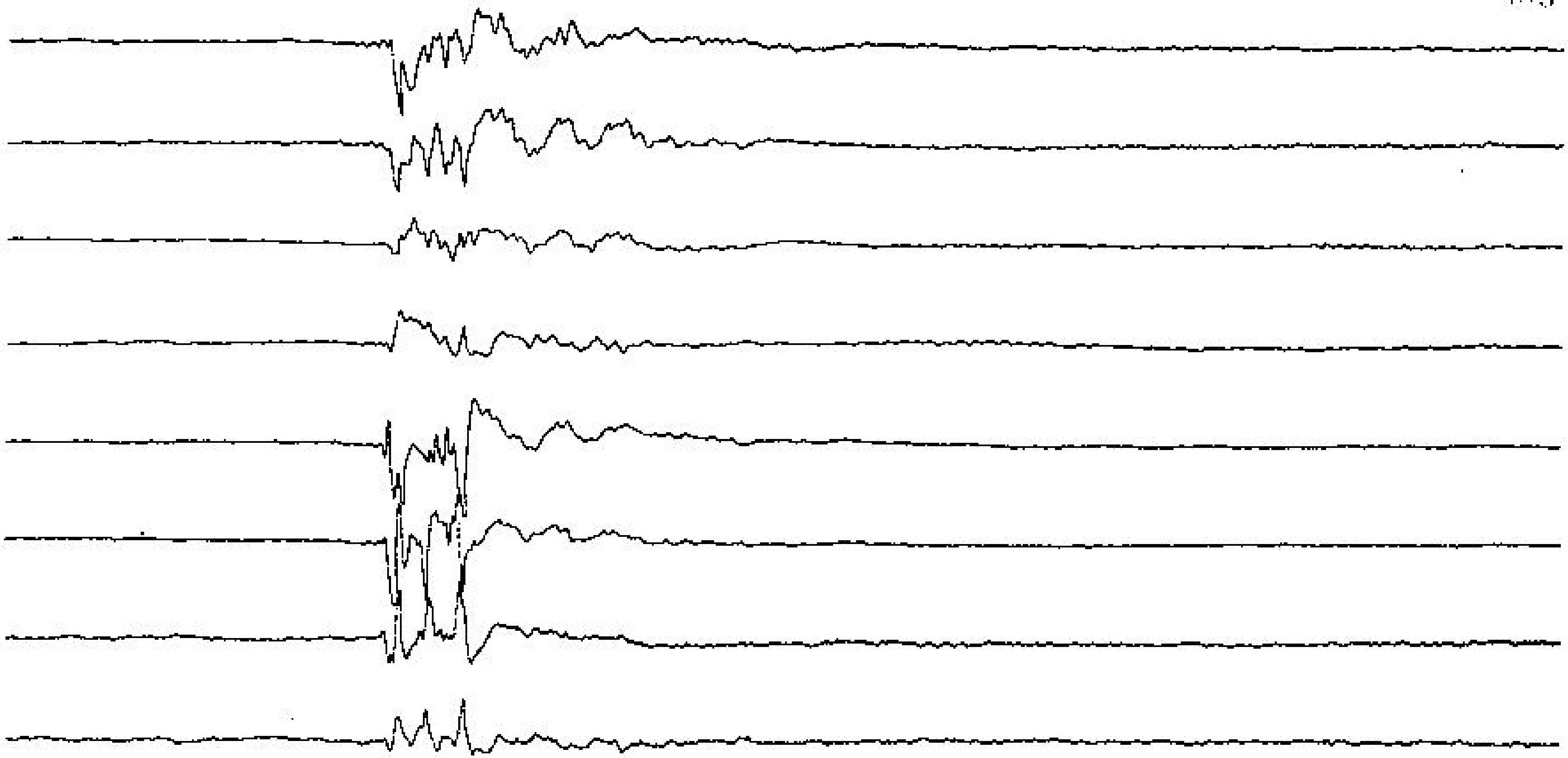
EMG-ref
140 uV
1 sec



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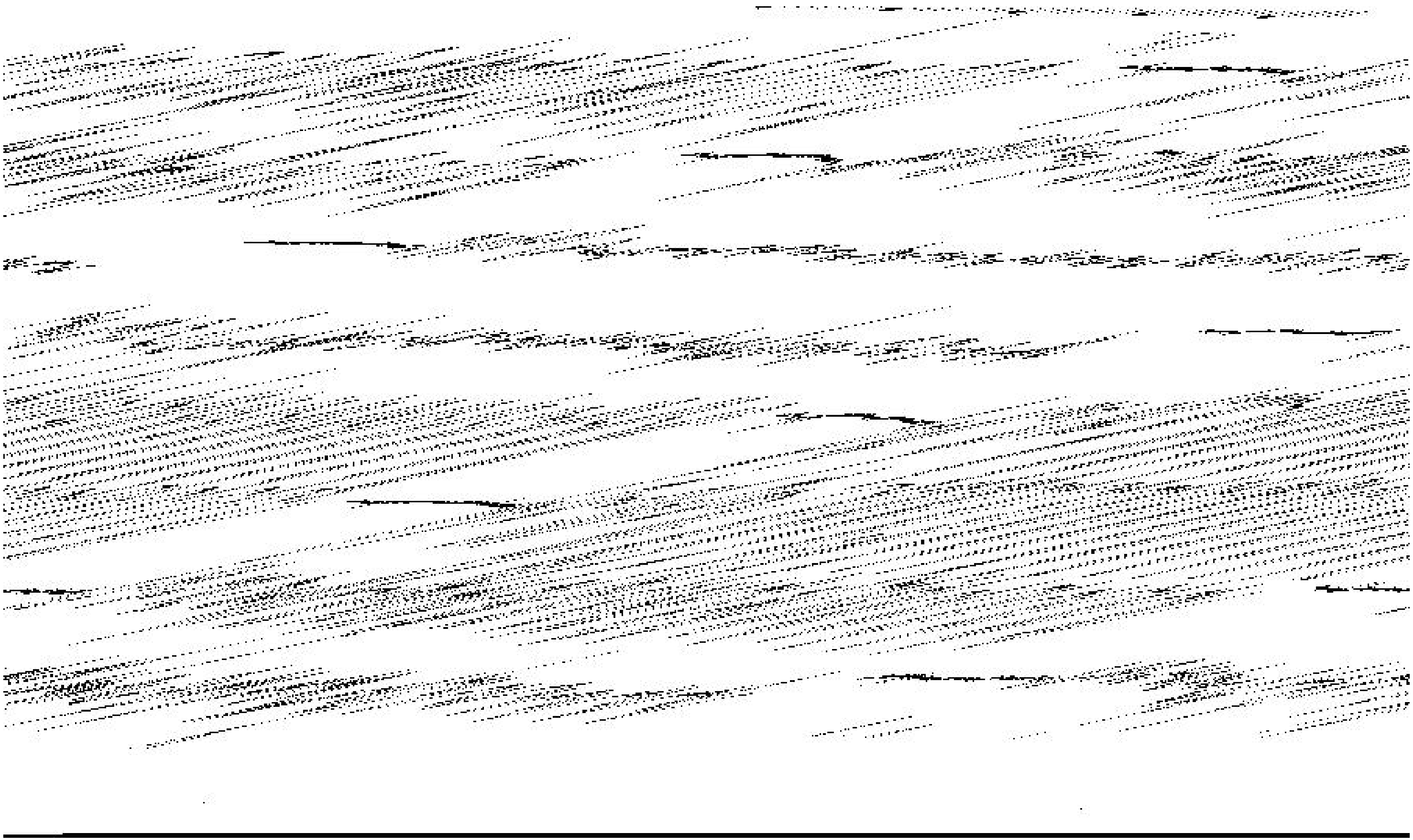

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neurocritical care society Neurocrit Care (2009) 11:210–216
DOI 10.1007/s12028-009-9236-6

ORIGINAL ARTICLE

Quantitative EEG Correlates of Low Cerebral Perfusion in Severe Stroke

Jennifer Diedler · Marek Sykora · Thomas Bast · Sven Poli · Roland Veltkamp · Patricio Mellado · Thorsten Steiner · André Rupp

Published online: 29 August 2009

Abstract
Introduction Continuous EEG provides the unique possibility to monitor neuronal function non-invasively. In our pilot study, we evaluated EEG spectral power during spontaneous drops in cerebral perfusion pressure (CPP) in deeply sedated and mechanically ventilated patients with severe stroke. We aimed to identify parameters that may be used for continuous monitoring even in patients with a burst-suppression baseline EEG pattern.
Methods Twenty ventilated and sedated patients with severe hemorrhagic or ischemic stroke underwent continuous EEG monitoring with synchronous CPP recording.
Results EEG monitoring duration was 83.9 hours on average per patient. Spectral power of EEG during drops of CPP was compared with epochs during normal CPP under the same levels of sedation. We found a significant decrease in faster EEG activity (3.5–20.7 Hz) during phases of low CPP (unaffected hemisphere $P < 0.01$, affected hemisphere $P < 0.01$, both $P < 0.01$).
Conclusion Despite considerable changes in baseline activity due to deep sedation and severe brain injury, we found evidence for disturbed neuronal function during drops in CPP. Thus, continuous EEG monitoring may add clinically relevant information on neuronal function in the setting of multimodality brain monitoring. Further studies are needed to implement real-time data analysis in the ICU setting.

Keywords Continuous EEG · Multimodality brain monitoring · Cerebral perfusion pressure · Stroke

Introduction

Continuous EEG monitoring is used in an increasing number of neurological intensive care units [1]. Typical applications include non-convulsive seizure detection [2, 3], outcome prediction [4–6], and sedation level assess-

Electroencephalography and clinical Neurophysiology 103 (1997) 607–615

Early detection of vasospasm after acute subarachnoid hemorrhage using continuous EEG ICU monitoring

Paul M. Vespa[a,*], Marc R. Nuwer[a], Csaba Juhász[b], Michael Alexander[c], Valeriy Nenov[d], Neil Martin[a], Donald P. Becker[a]

[a]Department of Neurology, UCLA, Reed Neurological Research Center, 710 Westwood Plaza, Los Angeles, CA 90024, USA
[b]Department of Neurosurgery, UCLA, Reed Neurological Research Center, 710 Westwood Plaza, Los Angeles, CA 90024, USA
[c]Department of Clinical Neurology, UCLA, Department of Neurology, Reed Neurological Research Center, 710 Westwood Plaza, Los Angeles, CA 90024, USA
[d]Department of Neurology, Semmelweis University Medical School, Budapest, Hungary

Accepted for publication: 13 June 1997

Abstract

The neurologic morbidity of delayed ischemic deficits from vasospasm following aneurysmal subarachnoid hemorrhage (SAH) continues to be the most debilitating complication from this devastating illness. Neurologic critical care is focused on recognition and treatment of these secondary insults but often the treatment is withheld until an irreversible deficit becomes manifest. Continuous EEG (cEEG) monitoring provides a unique potential to recognize early secondary insults and offers an opportunity for early intervention. We studied 32 SAH patients using cEEG and trending of the quantitative measure, relative alpha (RA), to determine if reductions in RA variability occurred with documented vasospasm. In 19/19 patients with angiographically documented vasospasm, we found that RA variability was decreased by a mean of two grades and improved with resolution of vasospasm. In 10/19 this reduction in RA variability preceded the diagnosis of vasospasm by a mean of 2.9 days (SD 1.73). The positive predictive and negative predictive values are 76% and 100%, respectively. Non-diagnostic clinical signs at the time of RA variability reduction and vasospasm were present in 12/19 patients. Thus decreased RA variability is able to provide early detection of neurologic complications such as vasospasm in patients before clear clinical symptoms and signs occur. © 1997 Elsevier Science Ireland Ltd.

ELSEVIER

Electroencephalography and clinical Neurophysiology 103 (1997) 607–615

Early detection of vasospasm after acute subarachnoid hemorrhage using continuous EEG ICU monitoring

Paul M. Vespa[a,*], Marc R. Nuwer[a], Csaba Juhász[b], Michael Alexander[c],

In 19/19 patients with angiographically documented vasospasm, we found that RA variability was decreased by a mean of two grades and improved with resolution of vasospasm.

In 10/19 this reduction in RA variability preceded the diagnosis of vasospasm by a mean of 2.9 days (SD 1.73).

The positive predictive and negative predictive values are 76% and 100%, respectively.

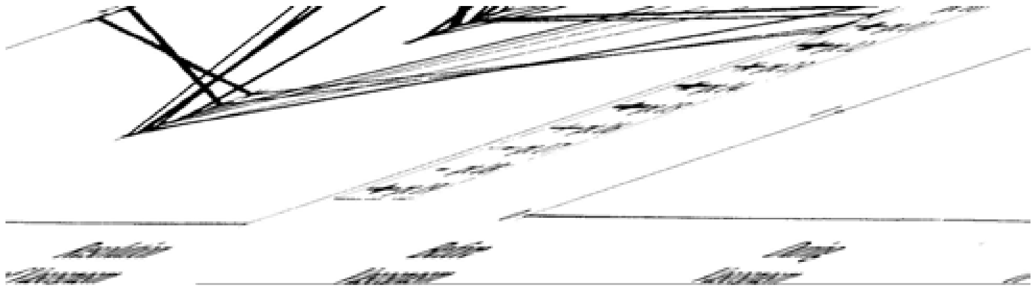
decreased by a mean of two grades and improved with resolution of vasospasm. In 10/19 this reduction in RA variability preceded the diagnosis of vasospasm by a mean of 2.9 days (SD 1.73). The positive predictive and negative predictive values are 76% and 100%, respectively. Non-diagnostic clinical signs at the time of RA variability reduction and vasospasm were present in 12/19 patients. Thus decreased RA variability is able to provide early detection of neurologic complications such as vasospasm in patients before clear clinical symptoms and signs occur.

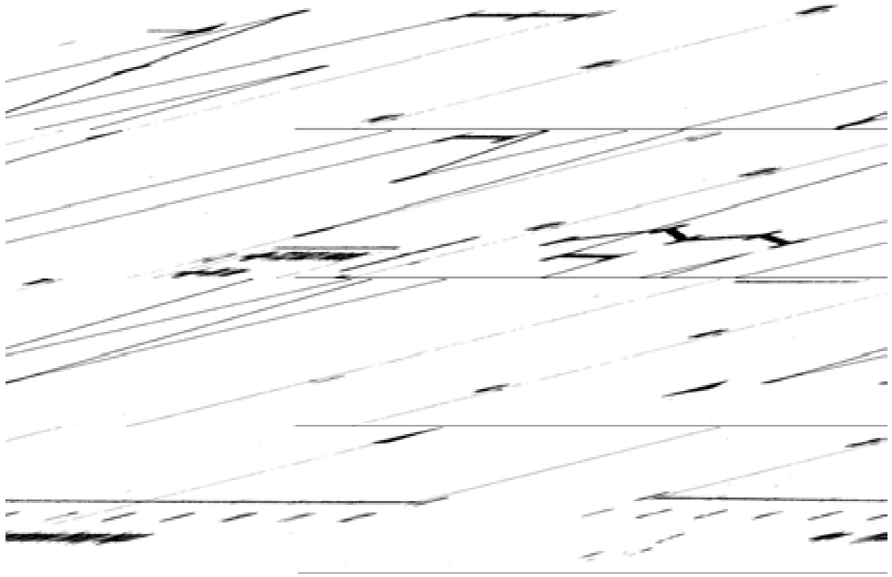
Poor RA Variability 1

Fair RA Variability 2

Good RA Variability 3

Excellent RA Variability 4





Intracortical Electroencephalography in Acute Brain Injury

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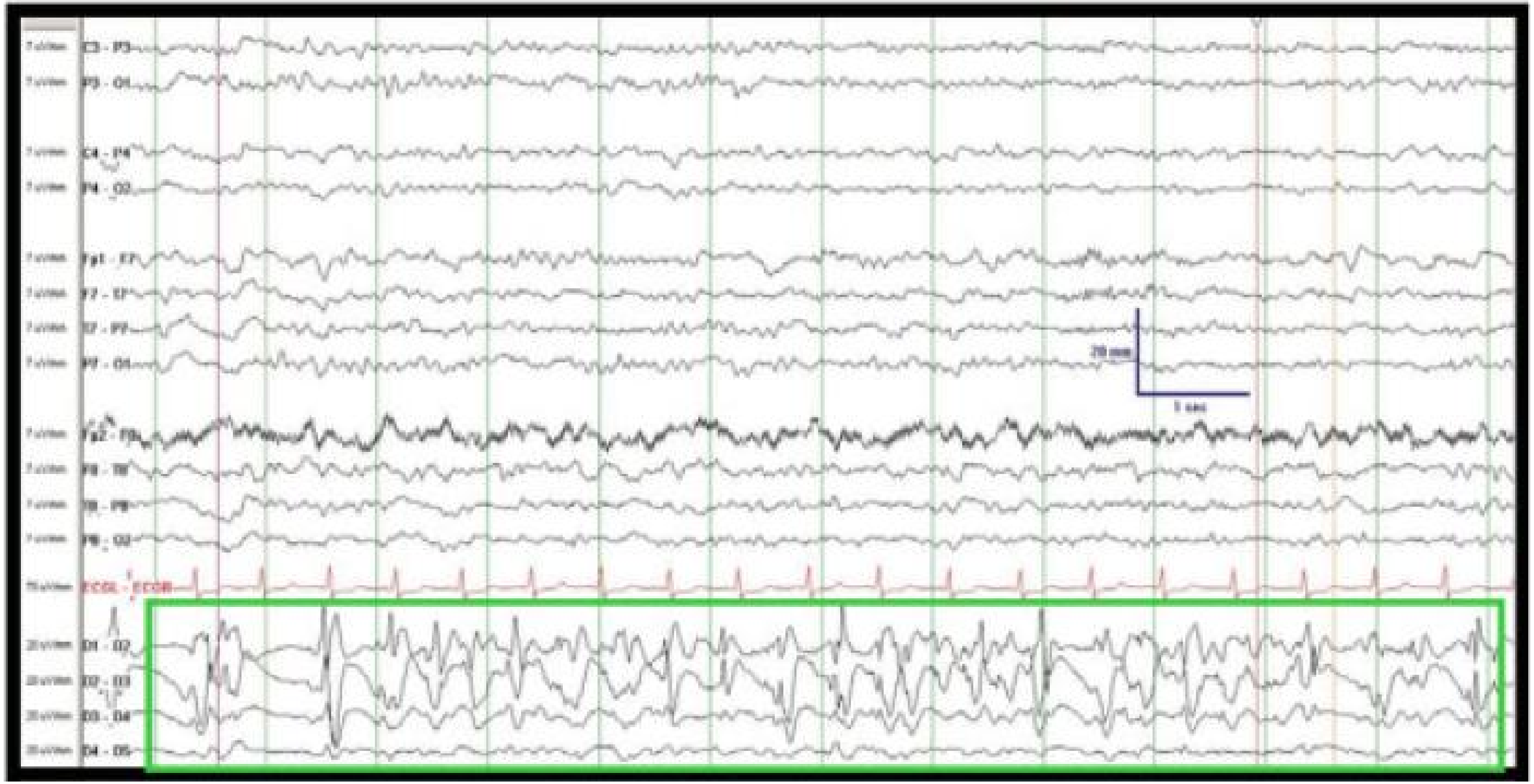
Objective: Continuous electroencephalography (EEG) is used in patients with neurological injury to detect electrographic seizures and clinically important changes in brain function. Scalp EEG has poor spatial resolution, is often contaminated by artifact, and frequently demonstrates activity that is suspicious for but not diagnostic of ictal activity. We hypothesized that bedside placement of an intracortical multicontact electrode would allow for improved monitoring of cortical potentials in critically ill neurological patients.

Methods: Sixteen individuals with brain injury, requiring invasive neuromonitoring, underwent implantation of an eight-contact minidepth electrode.

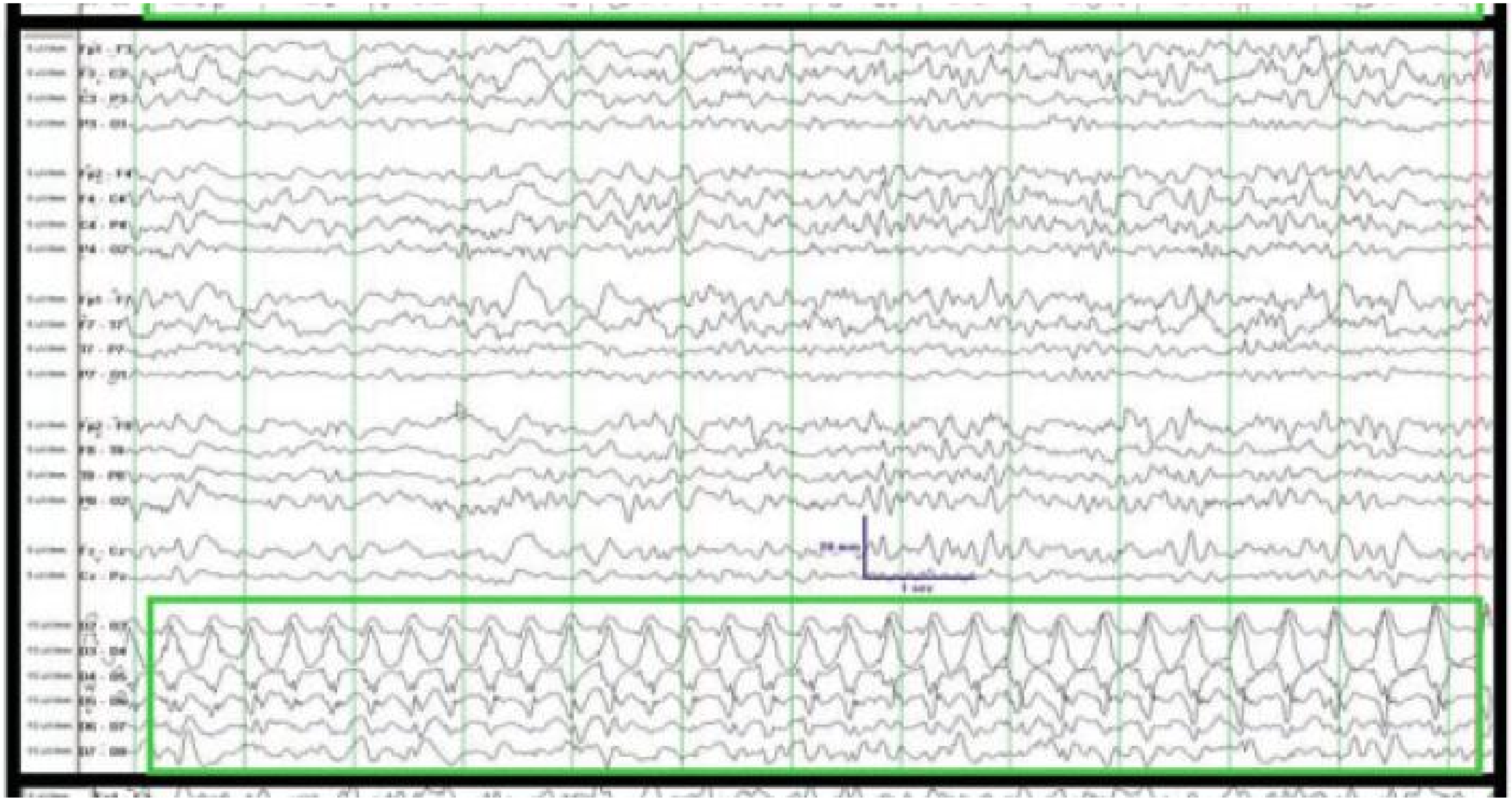
Results: Intracortical EEG (ICE) was successfully performed and compared with scalp EEG in 14 of these 16 individuals. ICE provided considerable improvement in signal-to-noise ratio compared with surface EEG, demonstrating clinically important findings in 12 of 14 patients (86%) including electrographic seizures (n = 10) and acute changes related to secondary neurological injury (n = 2, 1 ischemia, 1 hemorrhage). In patients with electrographic seizures detected by ICE, scalp EEG demonstrated no concurrent ictal activity in six, nonictal-appearing rhythmic delta in two, and intermittently correlated ictal activity in two. In two patients with secondary neurological complications, ICE demonstrated prominent attenuation 2 to 6 hours before changes in other neuromonitoring modalities and more than 8 hours before the onset of clinical deterioration.

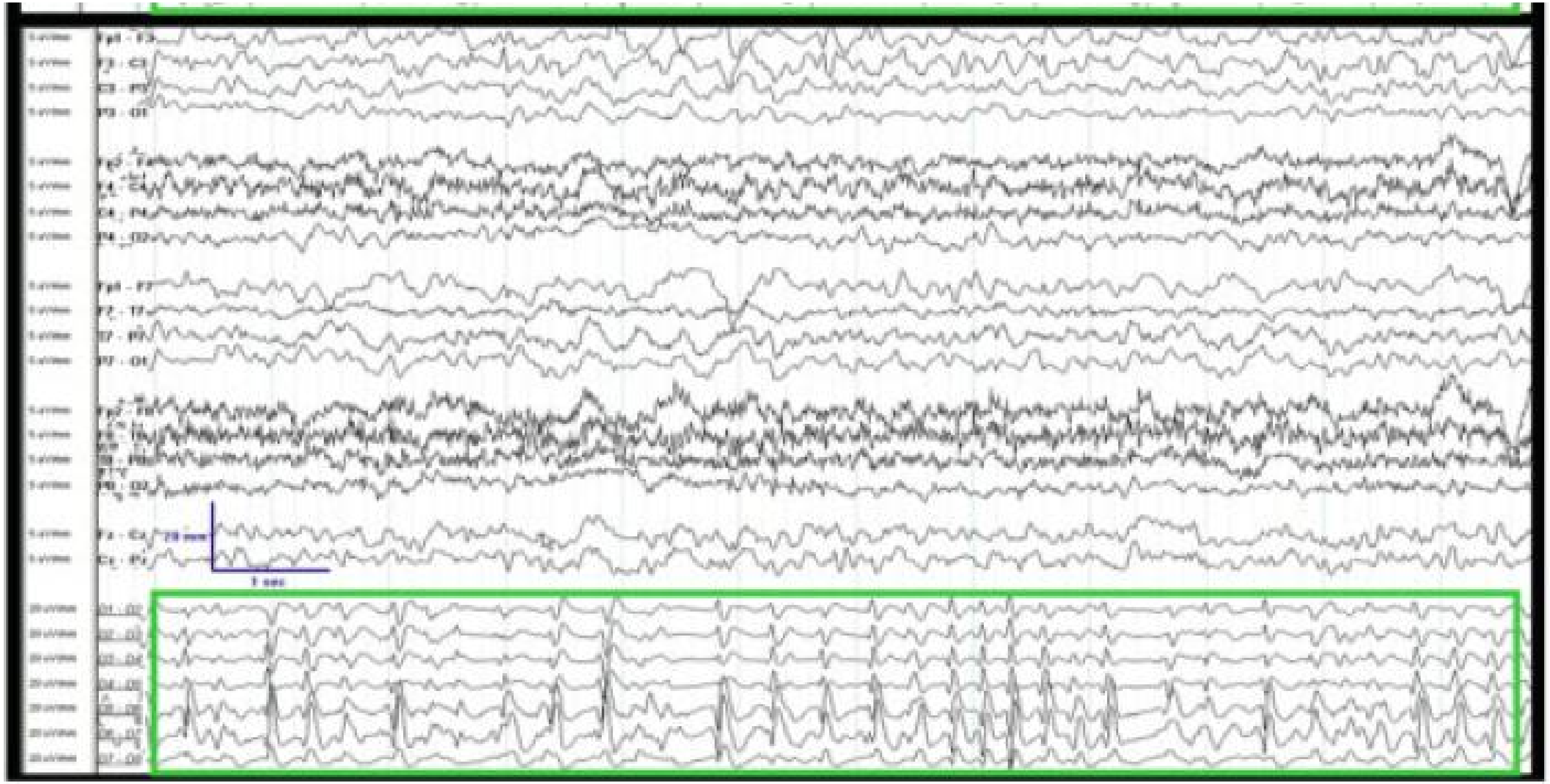
Interpretation: ICE can provide high-fidelity intracranial EEG in an intensive care unit setting, can detect ictal discharges not readily apparent on scalp EEG, and can identify early changes in brain activity caused by secondary neurological complications. We predict that ICE will facilitate the development of EEG-based alarm systems and lead to prevention of secondary neuronal injury.

Ann Neurol 2009;66:366–377

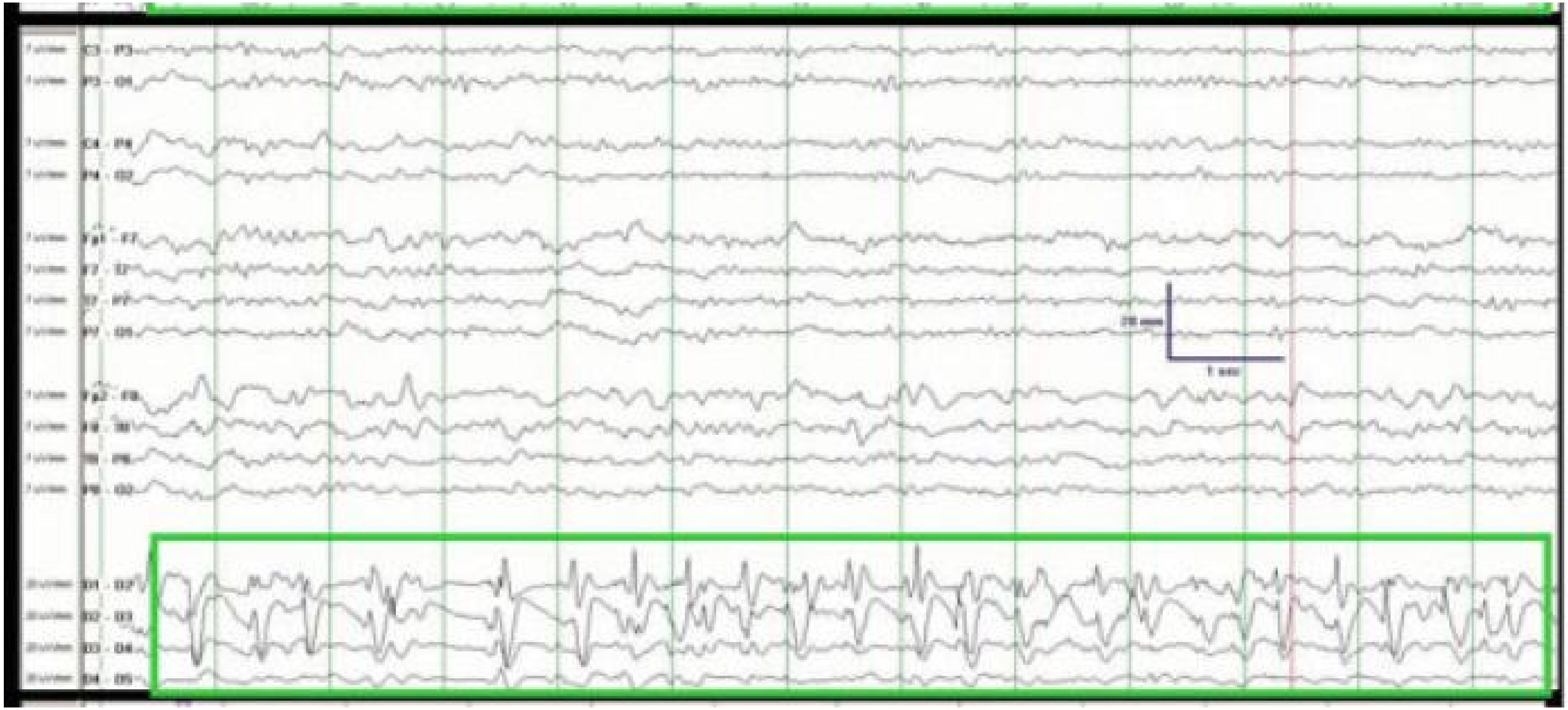


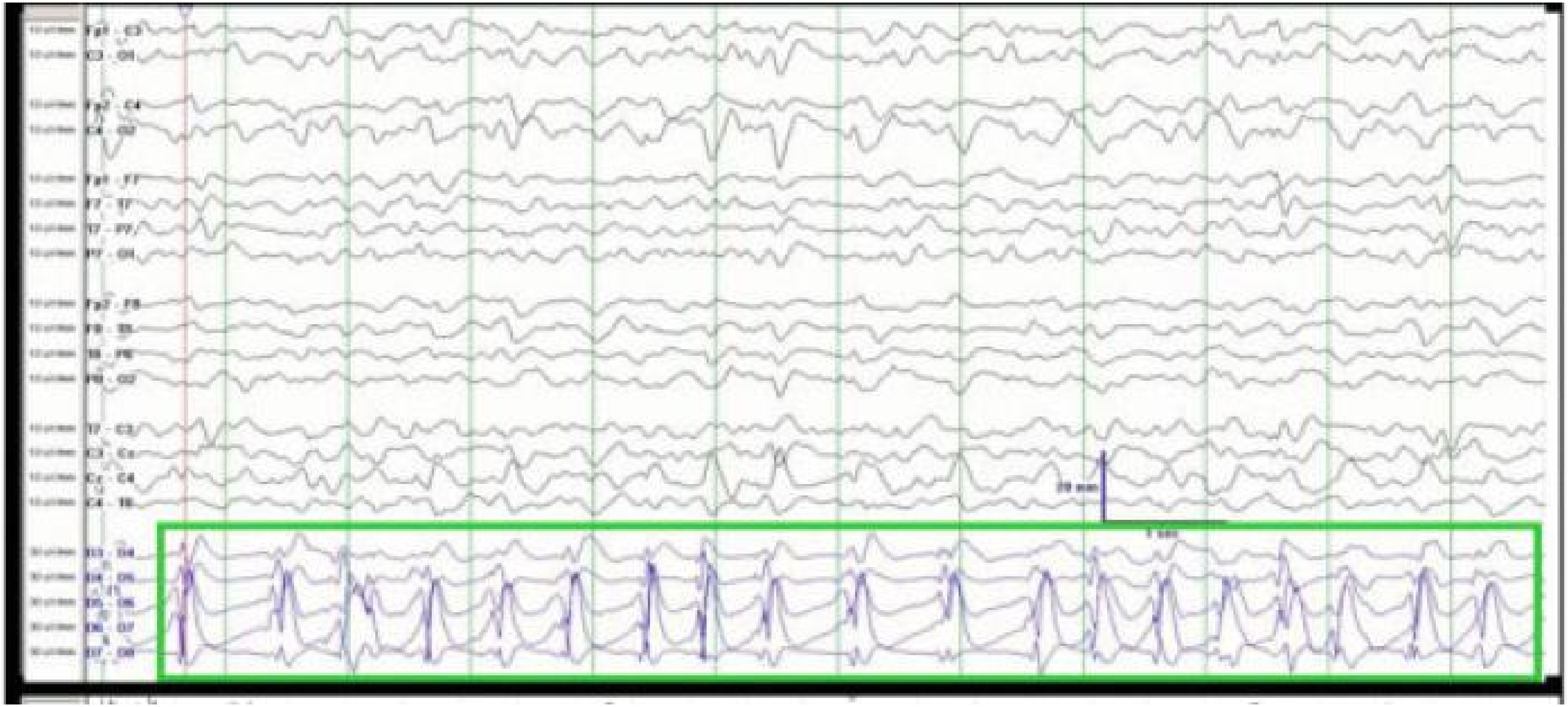
C3 - P3
C4 - P4
20 mm
1 sec
ECGL - ECGR
D1 - D2
D2 - D3
D3 - D4
D4 - D5

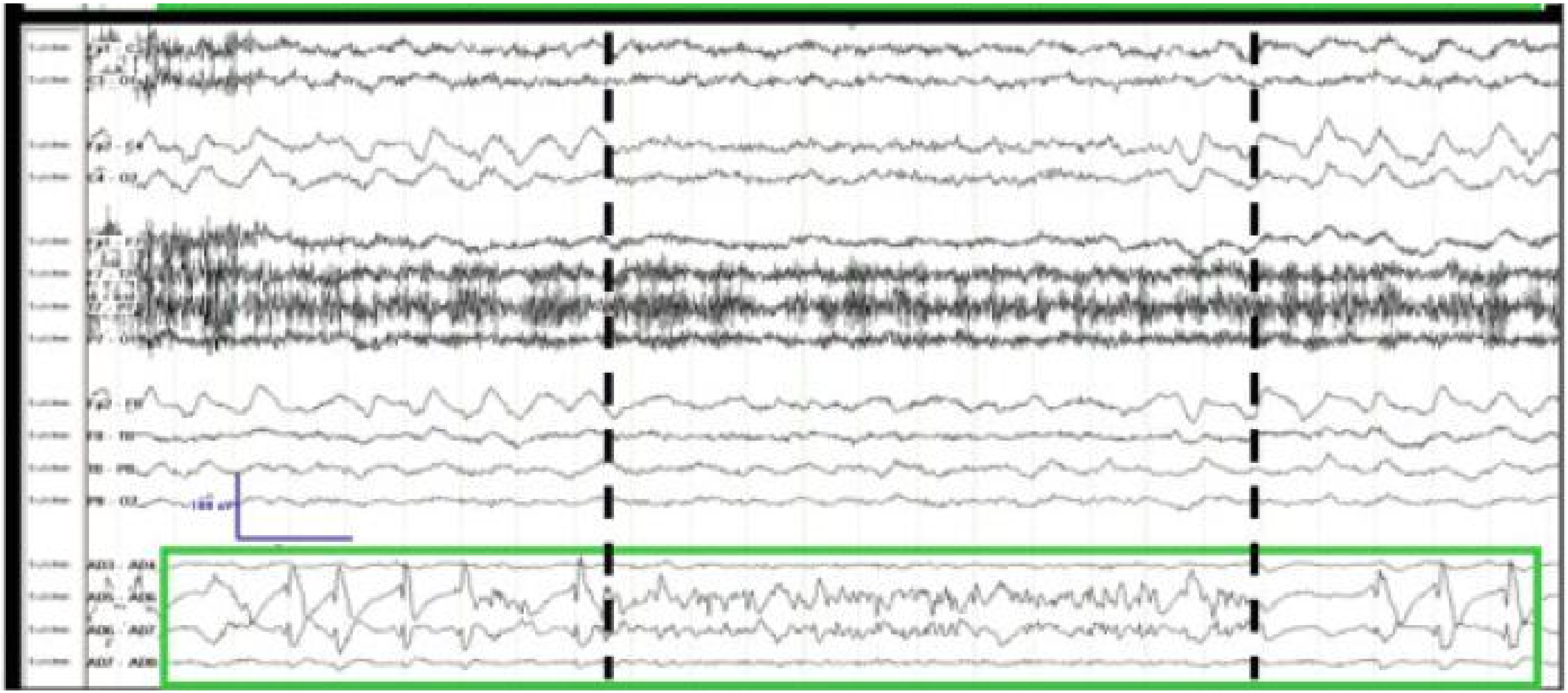





C3 - P3
P3 - O1
C4 - P4
P4 - O2
Fp1 - F7
F7 - T3
T3 - P7
P7 - O1
Fp2 - F8
F8 - T8
T8 - P8
P8 - O2
ECGL - ECGR
D1 - D2
D2 - D3
D3 - D4
D4 - D5
1 sec







American Clinical Neurophysiology Society's Standardized Critical Care EEG Terminology: 2012 version

L. J. Hirsch, S. M. LaRoche, N. Gaspard, E. Gerard, A. Svoronos, S. T. Herman, R. Mani, H. Arif, N. Jette, Y. Minazad, J. F. Kerrigan, P. Vespa, S. Hantus, J. Claassen, G. B. Young, E. So, P. W. Kaplan, M. R. Nuwer, N. B. Fountain, and F. W. Drislane

ACNS Standardized Critical Care EEG Terminology: 2012 version
Reference Chart

Main term 1
G *Generalized* *- Optional : Specify frontally, midline or occipitally predominant*
L *Lateralized* *- Optional: Specify unilateral or bilateral asymmetric* *- Optional: Specify lobe(s) most involved or hemispheric*
BI *Bilateral Independent* *- Optional: Specify symmetric or asymmetric* *- Optional: Specify lobe(s) most involved or hemispheric*
Mf *Multifocal* *- Optional: Specify symmetric or asymmetric* *- Optional: Specify lobe(s) most involved or hemispheric*

Main term 2
PD *Periodic Discharges*
RDA *Rhythmic Delta Activity*
SW *Rhythmic Spike and Wave* *OR* *Rhythmic Sharp and Slow Wave* *OR* *Rhythmic Polyspike and Wave*

Plus (+) Modifier
No +
+F *Superimposed fast activity – applies to PD or RDA only*
+R *Superimposed rhythmic activity – applies to PD only*
+S *Superimposed sharp waves or spikes, or sharply contoured - applies to RDA only*
+FR *If both subtypes apply – applies to PD only*
+FS *If both subtypes apply – applies to RDA only*

Major modifiers

Prevalence	Duration	Frequency	Phases[1]	Sharpness[2]	Absolute Amplitude	Relative Amplitude[3]	Polarity[2]	Stimulus Induced	Evolution[4]
Continuous ≥90%	**Very long** ≥1h	**≥4/s**	**>3**	**Spiky** <70ms	**High** ≥200μV	**>2**	**Negative**	**SI** *Stimulus Induced*	**Evolving**
Abundant 50-89%	**Long** 5-59min	**3.5/s**	**3**	**Sharp** 70-200ms	**Medium** 50-199μV	**≤2**	**Positive**	**Sp** *Spontaneous only*	**Fluctuating**
Frequent 10-49%	**Intermediate duration** 1-4.9min	**3/s**	**2**	**Sharply contoured** >200ms	**Low** 20-49μV		**Dipole**	**Unk** *Unknown*	**Static**
Occasional 1-9%	**Brief** 10-59s	**2.5/s**	**1**	**Blunt** >200ms	**Very low** <20μV		**Unclear**		
Rare <1%	**Very brief** <10s	**2/s**							
		1.5/s							
		1/s							
		0.5/s							
		<0.5/s							

Minor modifiers

Onset	Triphasic[5]	Lag
Sudden ≤3s	**Yes**	**A-P** *Anterior-Posterior*
Gradual >3s	**No**	**P-A** *Posterior-Anterior*
		No

NOTE 1: Applies to PD and and SW only, including the slow wave of the SW complex
NOTE 2: Applies to the predominant phase of PD and the spike or sharp component of SW only
NOTE 3: Applies to PD only
NOTE 4: Refers to frequency, location or morphology
NOTE 5: Applies to PD or SW only

Sporadic Epileptiform Discharges

Prevalence
Abundant ≥1/10s
Frequent 1/min-1/10s
Occasional 1/h-1/min
Rare <1/h

Background

Symmetry	Breach effect	PDR	Background EEG frequency	AP Gradient	Variability	Reactivity	Voltage	Stage II Sleep Transients	Continuity
Symmetric	**Present**	**Present** Specify frequency	**Delta**	**Present**	**Present**	**Present**	**Normal** ≥20μV	**Present and normal**	**Continuous**
Mild asymmetry ≤50% Amp. 0.5-1/s Freq.	**Absent**	**Absent**	**Theta**	**Absent**	**Absent**	**SIRPIDs only**	**Low** 10-20μV	**Present but abnormal**	**Nearly continuous:** ≤10% **periods of suppression** (<10μV) or **attenuation** (≥10μV but <50% of background voltage)
Marked asymmetry >50% Amp. >1/s Freq.	**Unclear**		**≥Alpha**	**Reverse**	**Unclear**	**Absent**	**Suppressed** <10μV	**Absent**	**Discontinuous:** 10-49% **periods of suppression** or **attenuation**
						Unclear			**Burst-suppression** or **Burst-attenuation:** 50-99% **periods of** suppression or **attenuation**
									Suppression

TABLE 1. New Terms for Older Terms

OLD Term		NEW Term
Triphasic waves, most of record	=	continuous 2/s GPDs (with triphasic morphology)
PLEDs	=	LPDs
BIPLEDs	=	BIPDs
GPEDs/PEDs	=	GPDs
FIRDA	=	Occasional frontally predominant brief 2/s GRDA (if 1-10% of record)
PLEDS+	=	LPDs+
SIRPIDs* w/ focal evolving RDA	=	SI-Evolving LRDA
Lateralized seizure, delta frequency	=	Evolving LRDA
Semirhythmic delta	=	Quasi-RDA

*SIRPIDs = stimulus-induced rhythmic, periodic or ictal discharges.

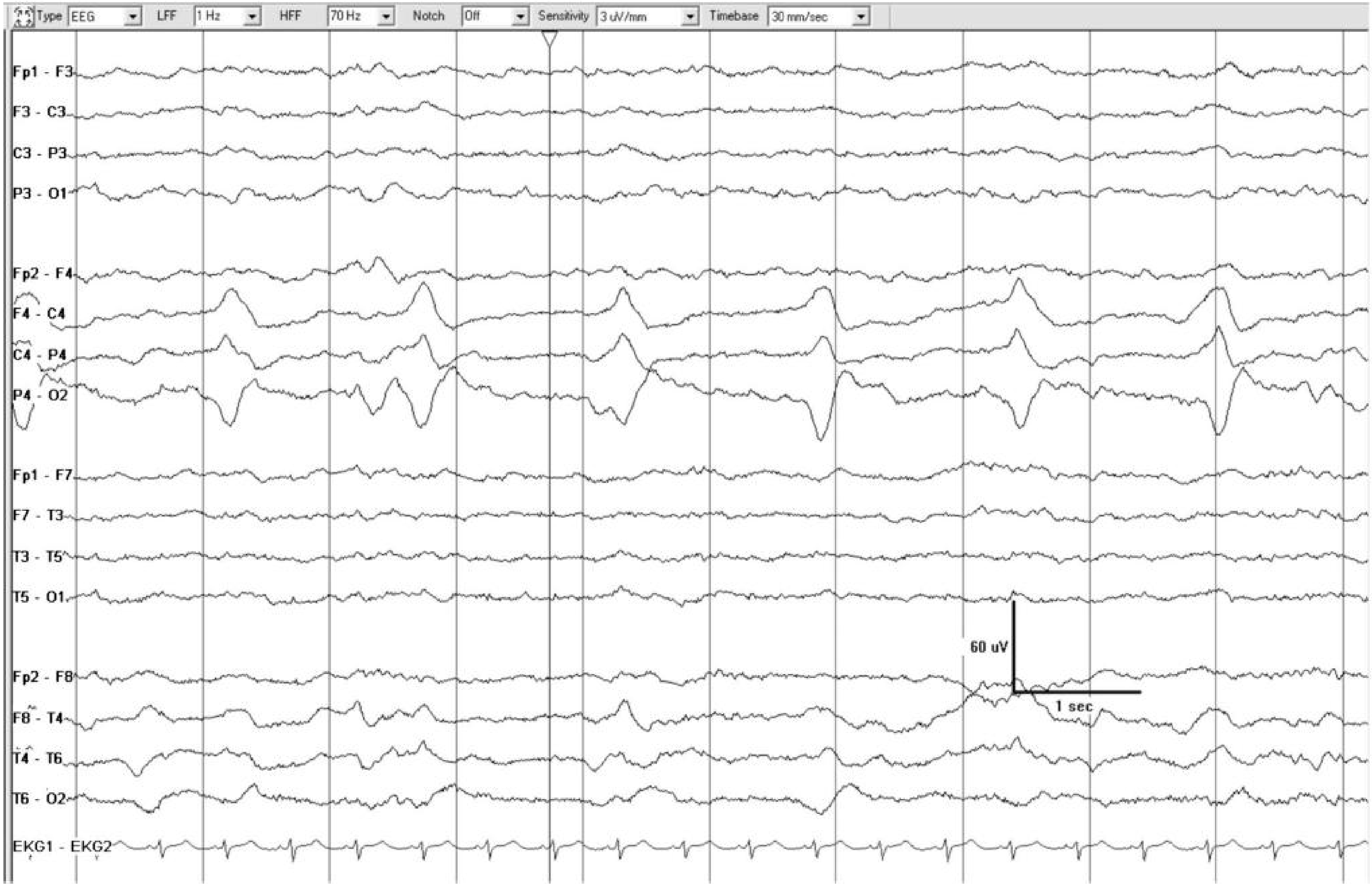


FIG. 1. LPDs: Sharply contoured lateralized periodic discharges. In this case, LPDs are unilateral.

FIG. 2. LPDs: Sharply contoured lateralized periodic discharges. In this case, PDs are bilateral asymmetric.

FIG. 3. LPDs: Sharply contoured lateralized periodic discharges. In this case, PDs are bilateral asymmetric. Although some discharges are on the border of sharp, most are sharply contoured.

FIG. 4. LPDs: 0.5 per second spiky lateralized periodic discharges.

FIG. 5. LPDs: 0.5-1 per second spiky lateralized periodic discharges. Despite their spike-and-wave morphology, the discharges are periodic (as there is a quantifiable inter-discharge interval between consecutive waveforms and recurrence of the waveform at nearly regular intervals).

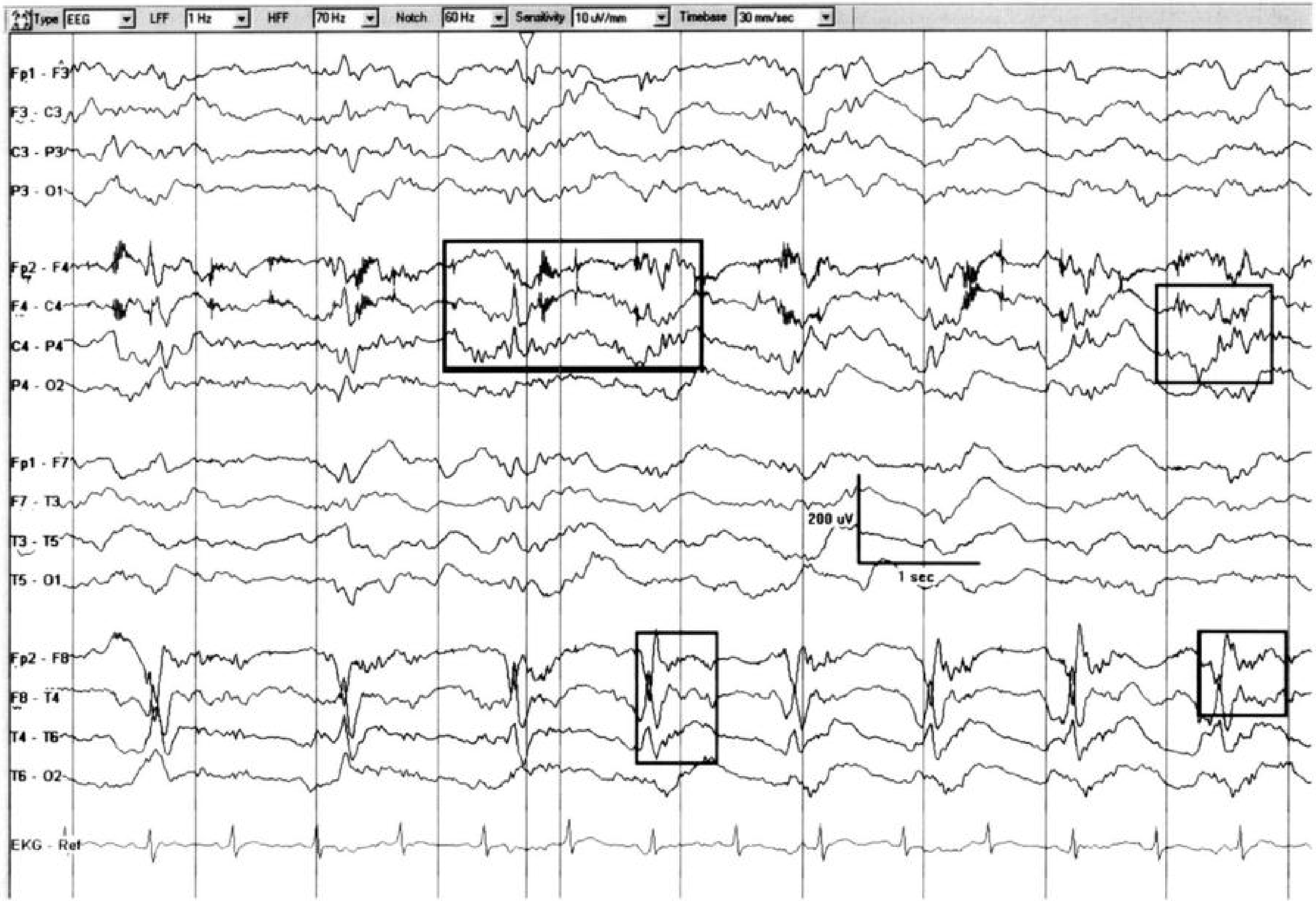


FIG. 6. LPDs+F: 0.5 to 1 per second spiky LPDs with superimposed burst of low amplitude fast activity (highlighted in boxes).

FIG. 7. LPDs+R: Irregular (in morphology and repetition rate) 0.5-1 per second quasi-periodic discharges with superimposed quasi-rhythmic delta activity in the right hemisphere with occasional spread to the left. Less "stable" pattern and more ictal-appearing than LPDs alone; compare with Figure 1.

FIG. 8. Fluctuating LPDs: Lateralized periodic discharges that fluctuate in frequency between 0.5 and 1 per second.

FIG. 9. GPDs: One per second sharp generalized periodic discharges.

FIG. 10. GPDs with triphasic morphology and A-P lag: Generalized periodic discharges at just under 1.5 per second. In this case there is also a triphasic morphology and an anterior-posterior lag, highlighted with the diagonal line in the upper right of the figure.

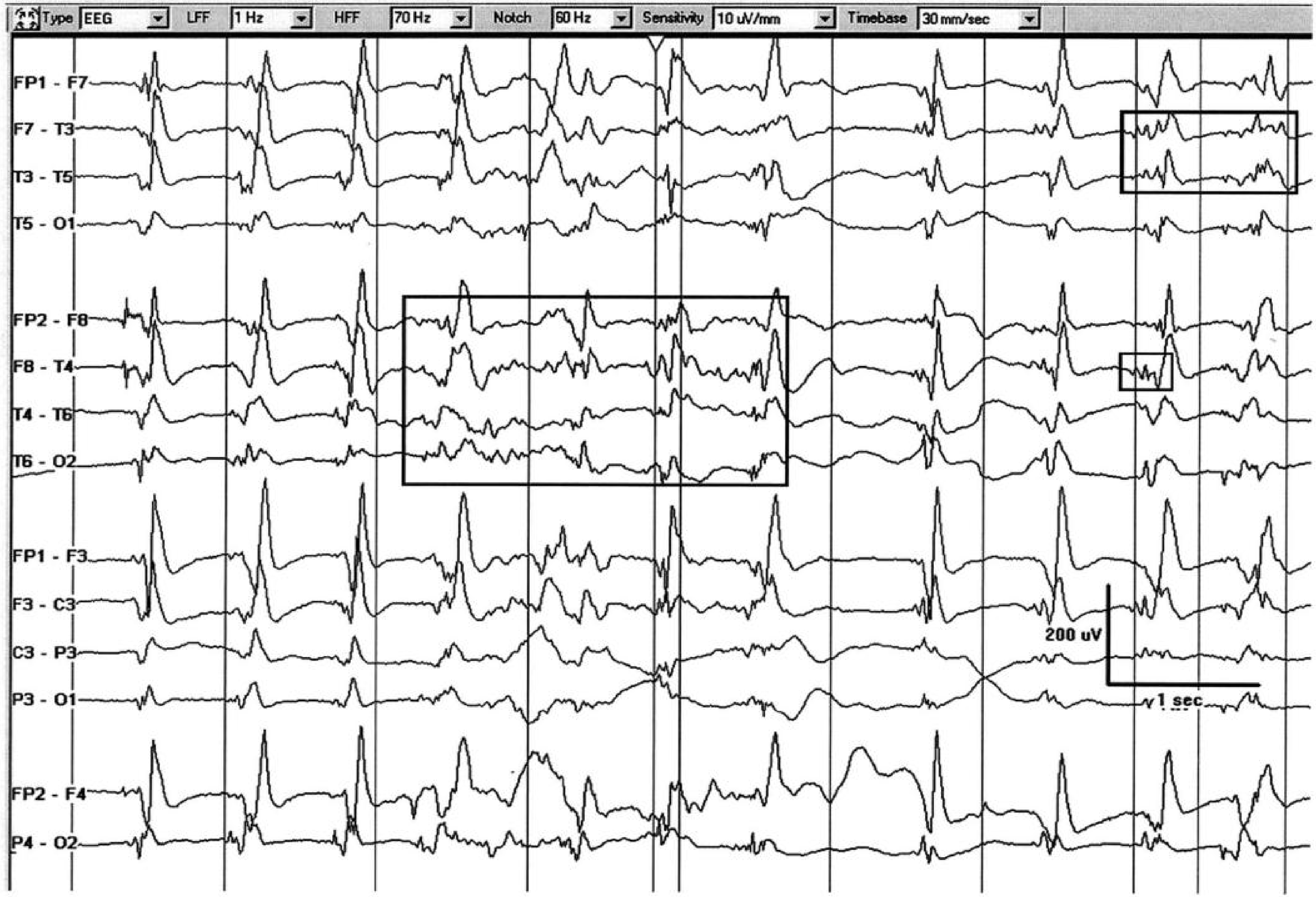


FIG. 11. GPDs+F: 1-1.25 per second sharp GPDs with superimposed low amplitude quasi-rhythmic sharp activity (highlighted in boxes).

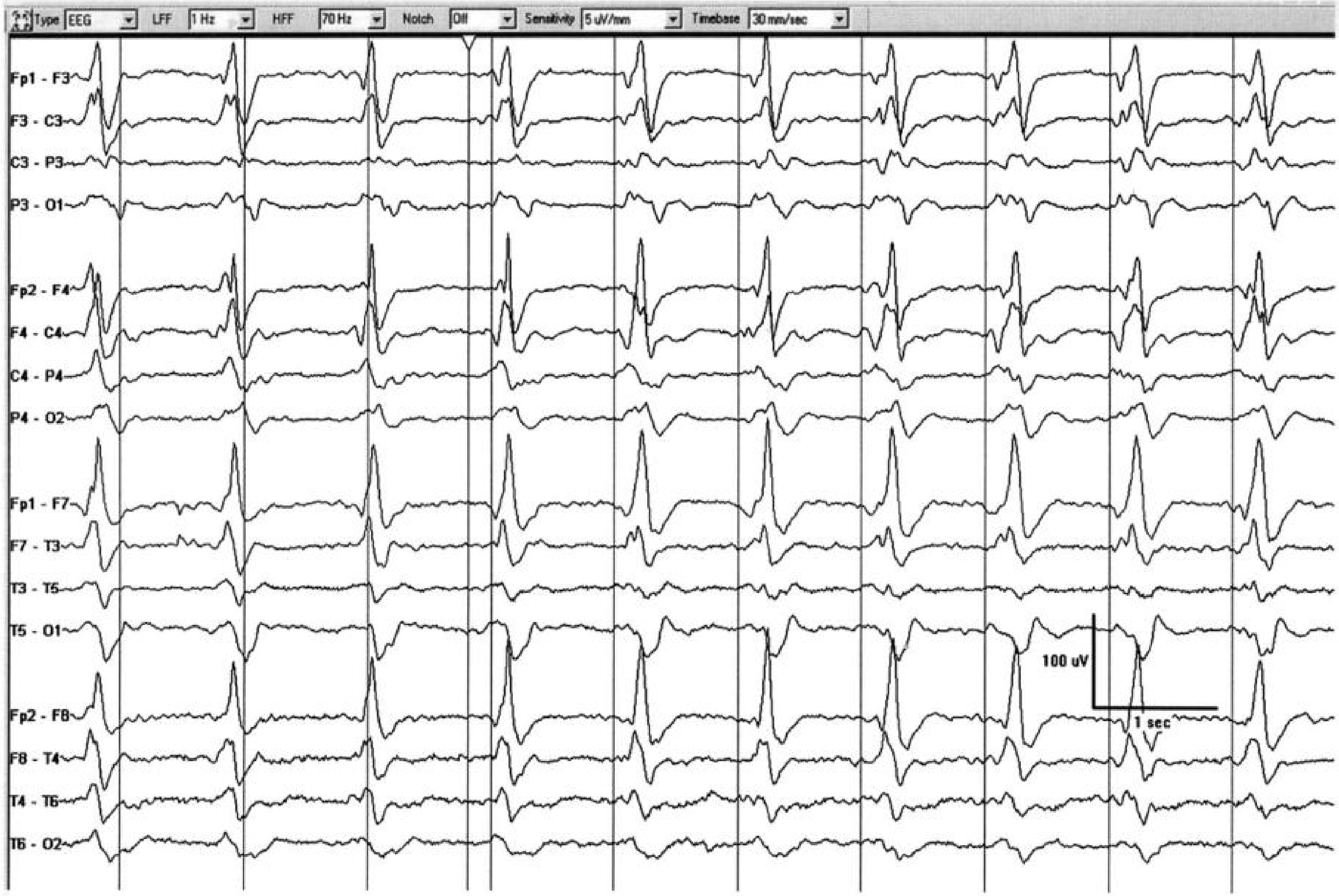


FIG. 12. GPDs: One per second generalized periodic discharges, characterized by a marked frontal predominance and a sharp morphology. Despite background attenuation, the discharges last less than 500ms and thus do not qualify as bursts.

FIG. 13. BIPDs+F: Bilateral independent periodic discharges at 0.5-1 per second, most prominent centroparietally on both sides. The periodic discharges have a sharp morphology and are associated with low amplitude sharply contoured quasi-rhythmic fast activity, especially posteriorly, and more prominent on the right where the fast activity is nearly continuous.

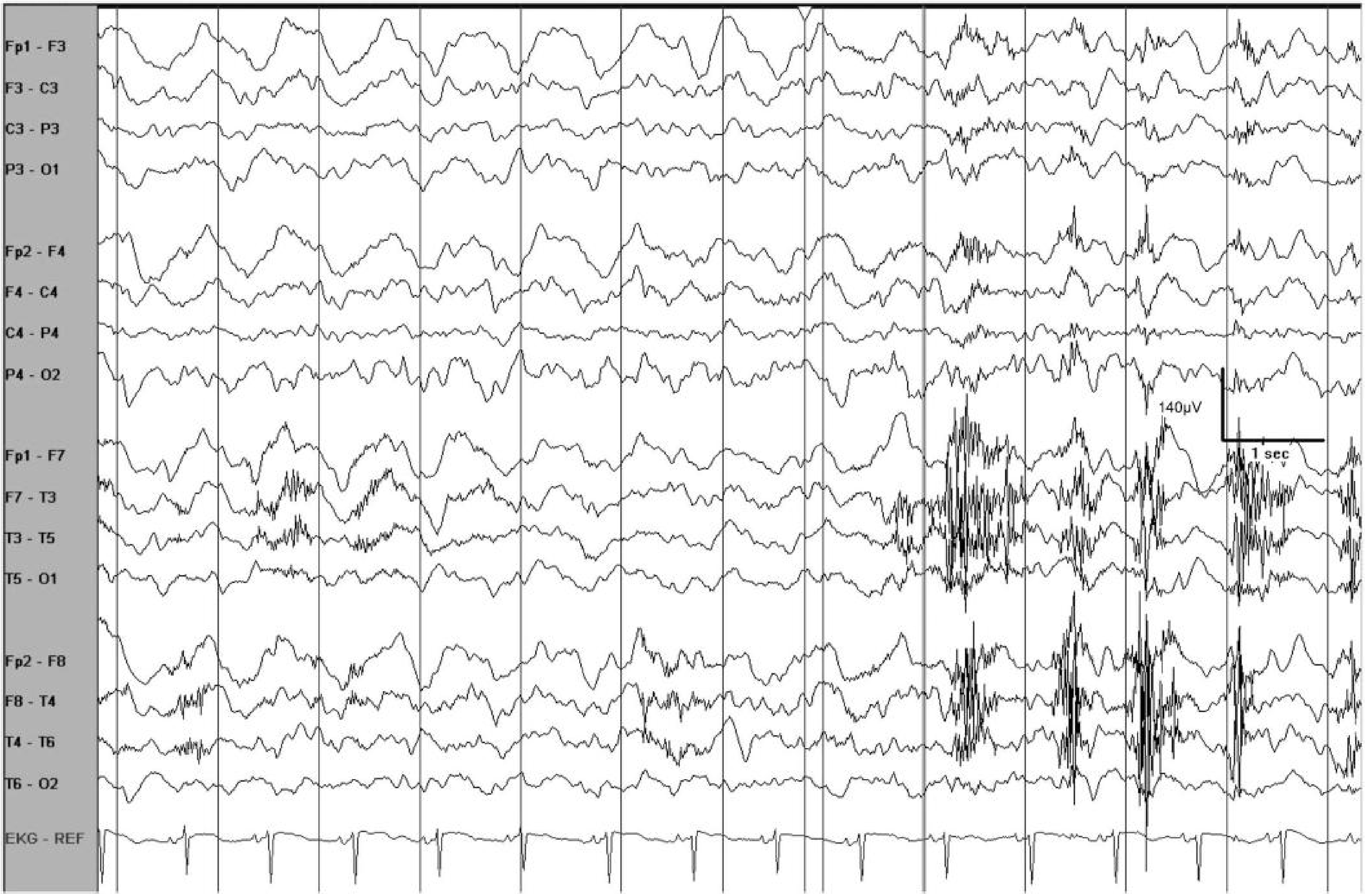


FIG. 14. GRDA: Generalized rhythmic delta activity, frontally predominant. If the lower amplitude faster (α range) frequencies are not present in the background when the GRDA is not present, then this would qualify as GRDA+F.

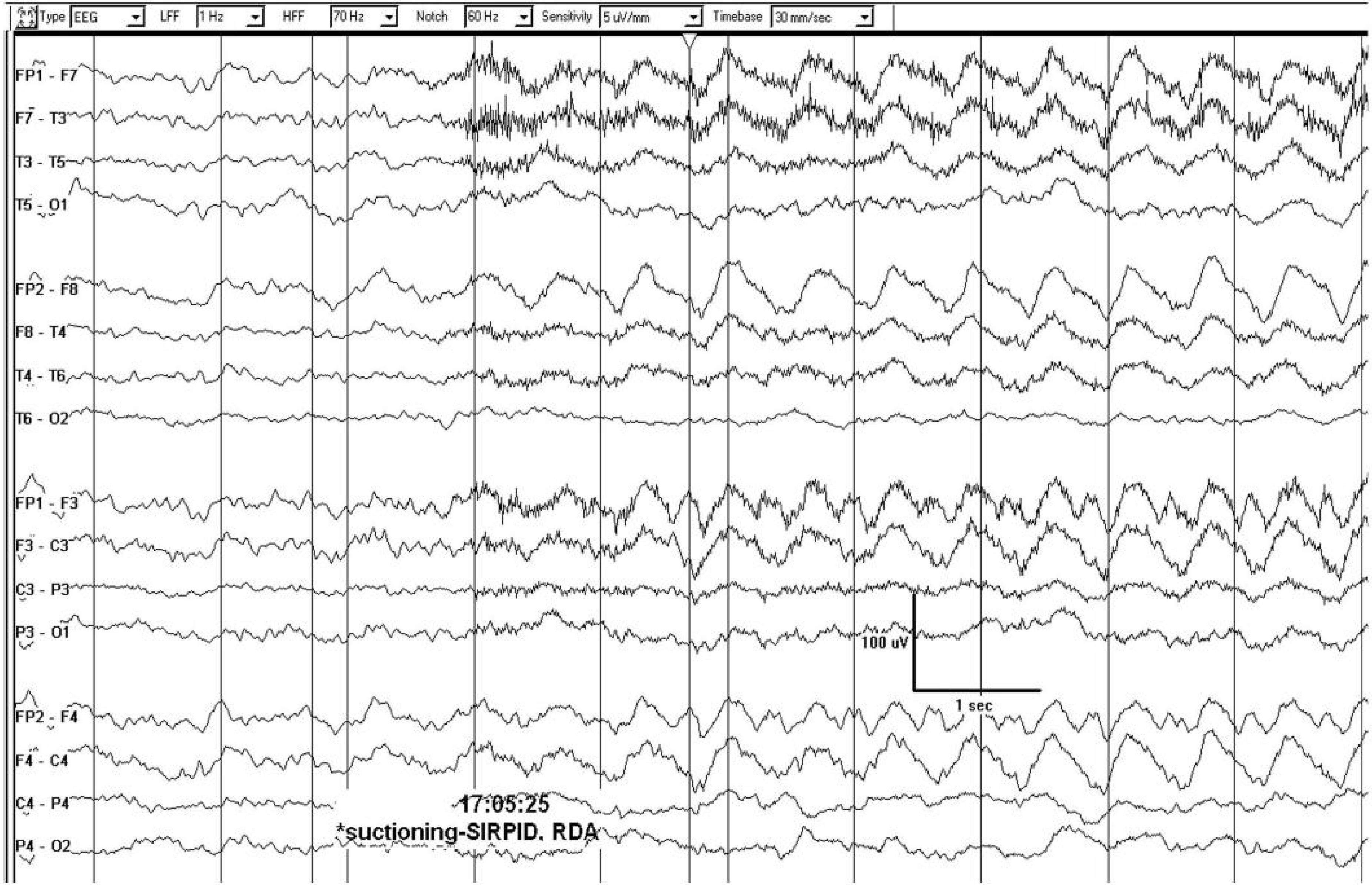


FIG. 15. SI-GRDA: Stimulus-induced generalized rhythmic delta activity, frontally predominant. In this case, the pattern was elicited by suctioning the patient.

FIG. 16. Evolving LRDA: Lateralized rhythmic delta activity that evolves in morphology and frequency. It begins as low voltage sharply contoured 1.5 Hz delta in the left parasagittal region, evolves to 3 Hz rhythmic delta, then again slows.

FIG. 17. Evolving LRDA: Lateralized rhythmic delta activity that evolves in frequency and morphology from a 4 per second blunt RDA to a 2.5 per second sharply contoured RDA.

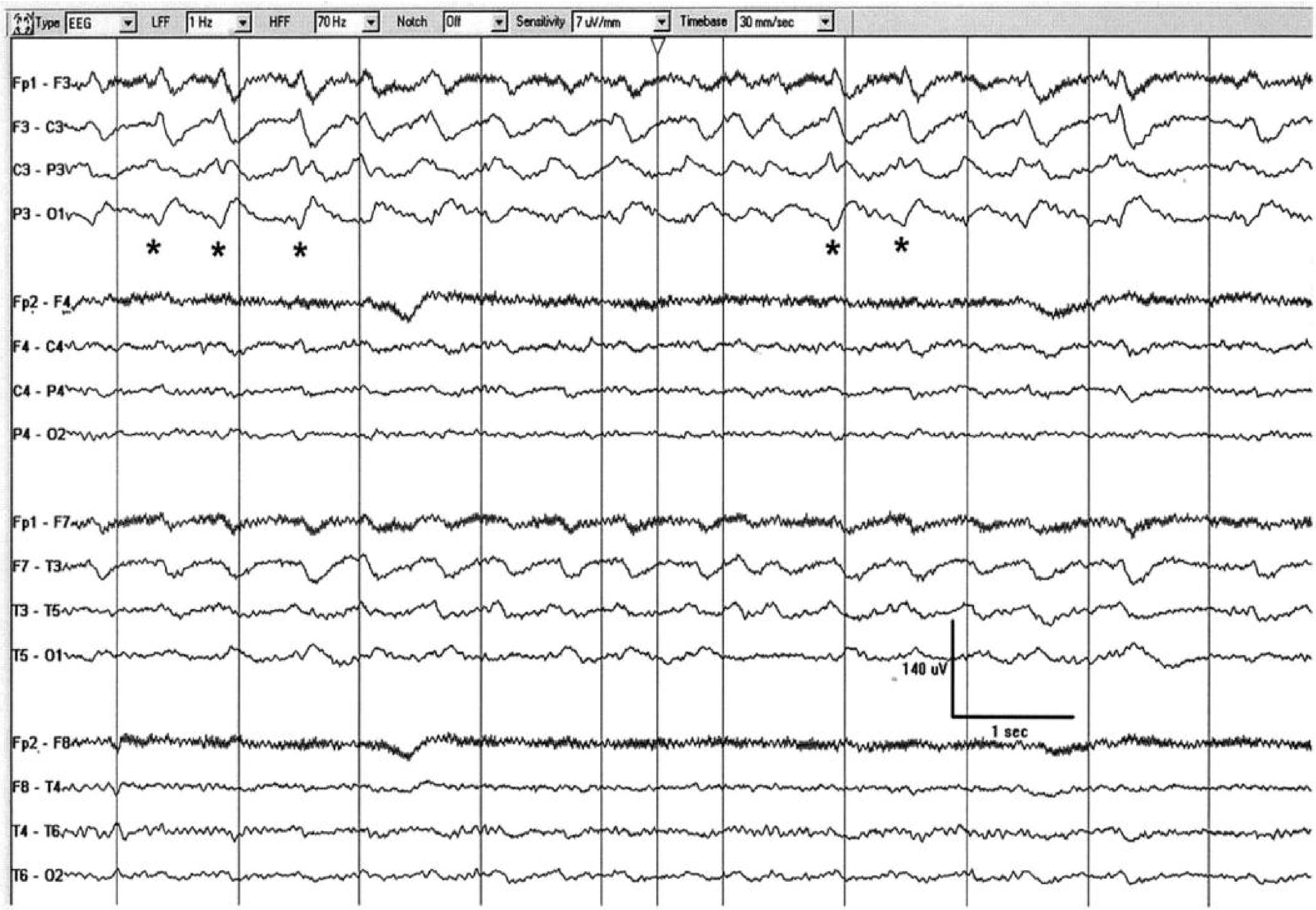


FIG. 18. LRDA+S: Two per second lateralized rhythmic delta activity with superimposed repetitive sharp waves (several marked with asterisks). The superimposed low amplitude fast activity is also present on the right hemisphere and should not be recorded as +F.

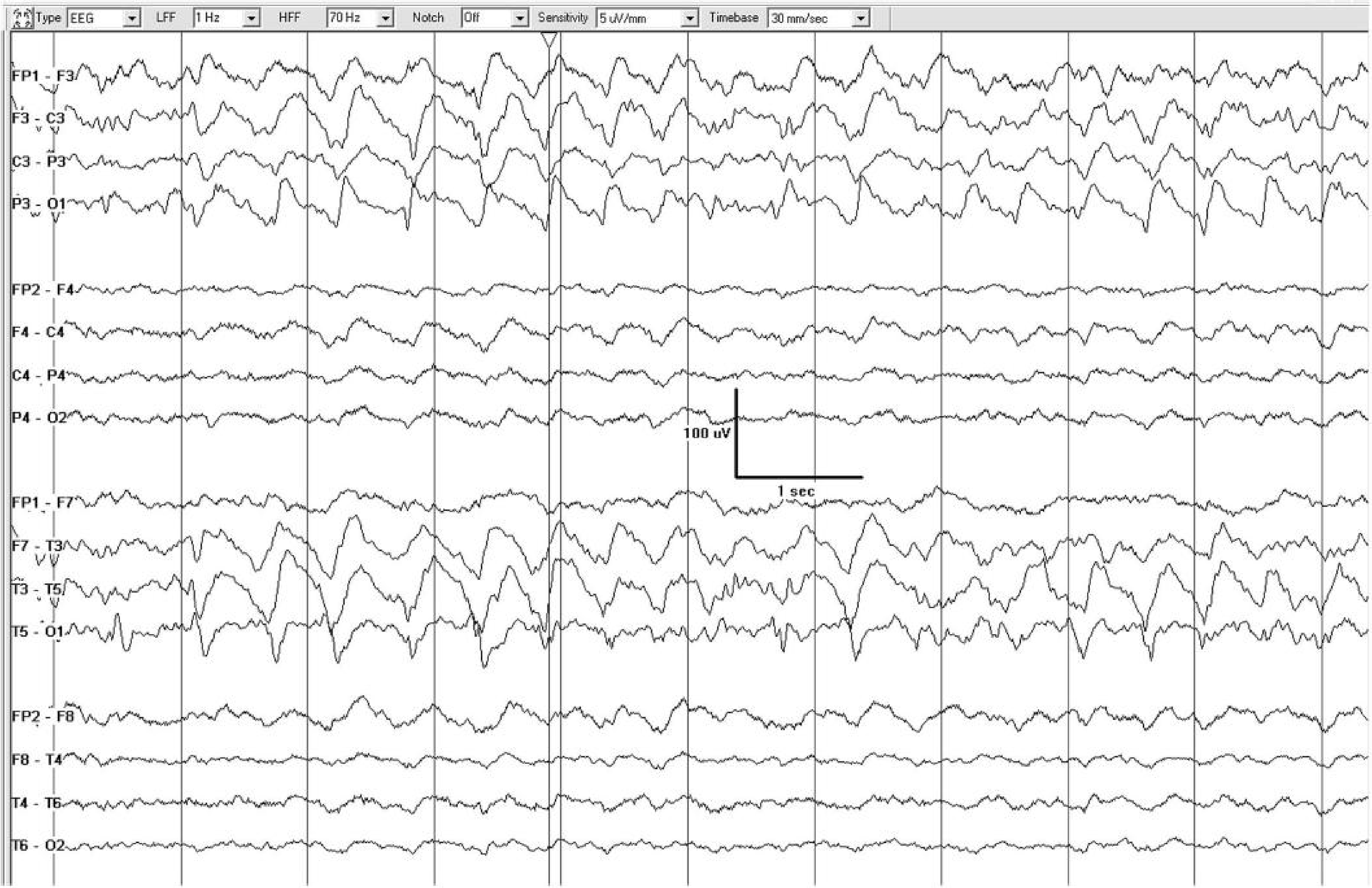


FIG. 19. LRDA+S: Two per second lateralized rhythmic delta activity with superimposed sharp waves most prominent in the left parasagittal region. The superimposed low amplitude fast activity is also present on the right hemisphere and could be recorded as +F if not present in the background (i.e., in the absence of the rhythmic delta activity).

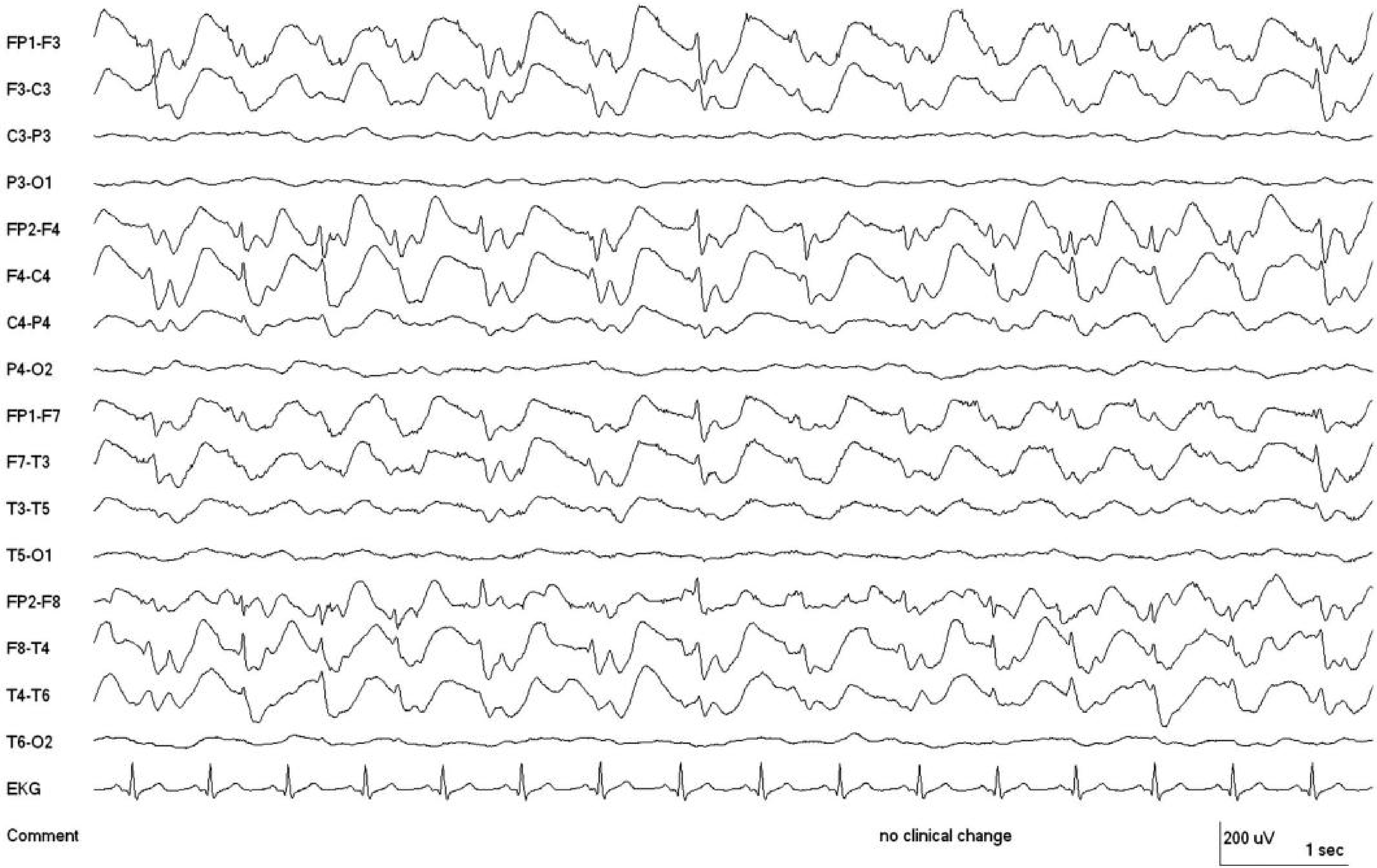


FIG. 20. GSW: 1.5 per second generalized polyspike-and-wave, frontally predominant. A polyspike precedes every slow wave and there is no inter-discharge interval; thus this pattern does not qualify for GRDA+S or GPDs+R.

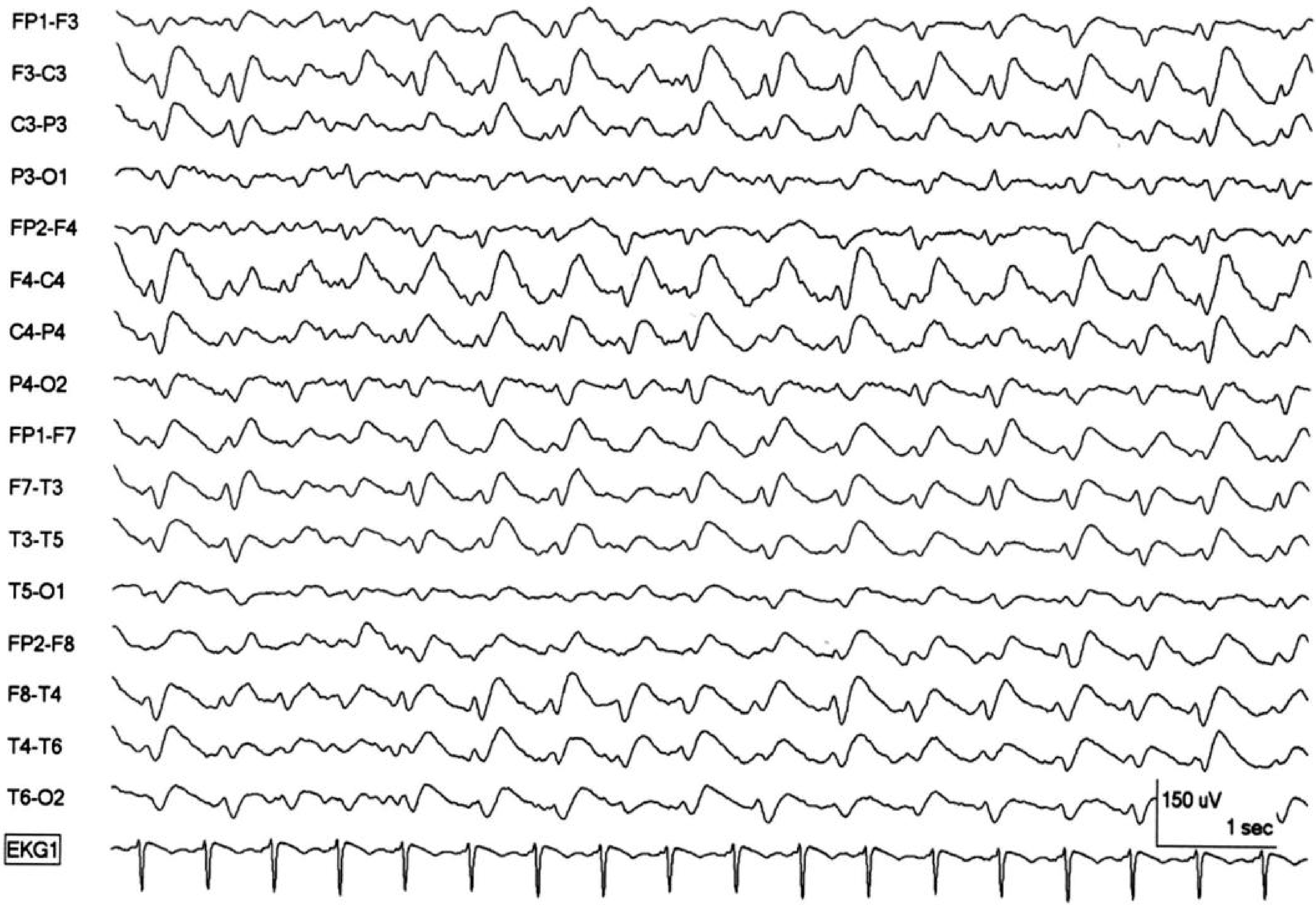


FIG. 21. GSW: 1.5 per second generalized spike-and-wave.

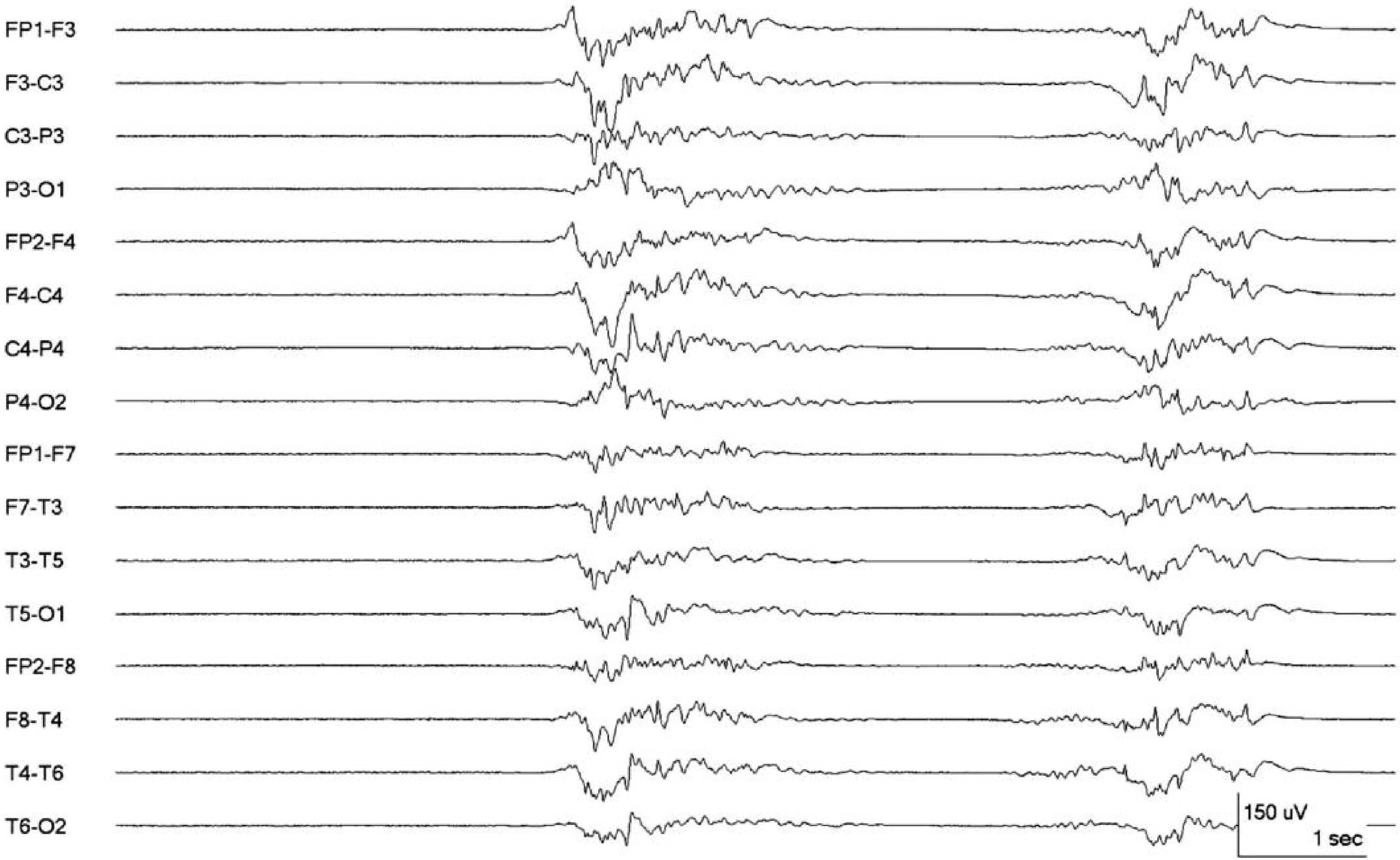


FIG. 22. Burst-suppression pattern: Bursts (>500ms AND >3phases) of generalized activity on a suppressed (<10 μV) background.

FIG. 23. Burst-attenuation pattern: In between bursts of generalized activity, there is low amplitude background activity (<50% of the background/bursts, but >10 μV).

For the slides, email me at

- tbleck@gmail.com