Chulalongkorn University
จุฬาลงกรณ์มหาวิทยาลัย
Pillar of the Kingdom

Chulalongkorn Comprehensive Epilepsy Centre

EEG INTERPRETATION PRINCIPLES

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Talk overview

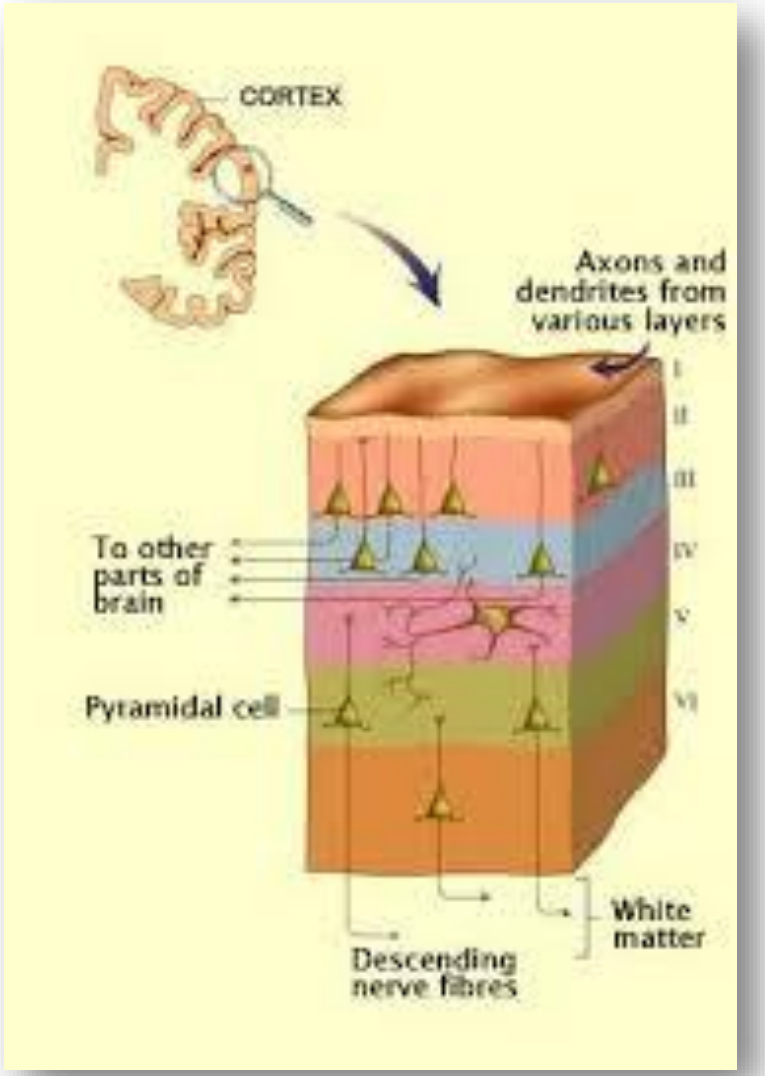
1. Generator of brain waves
2. EEG polarity
3. EEG montages
4. Systematic approach to EEG interpretation
5. Normal EEG patterns

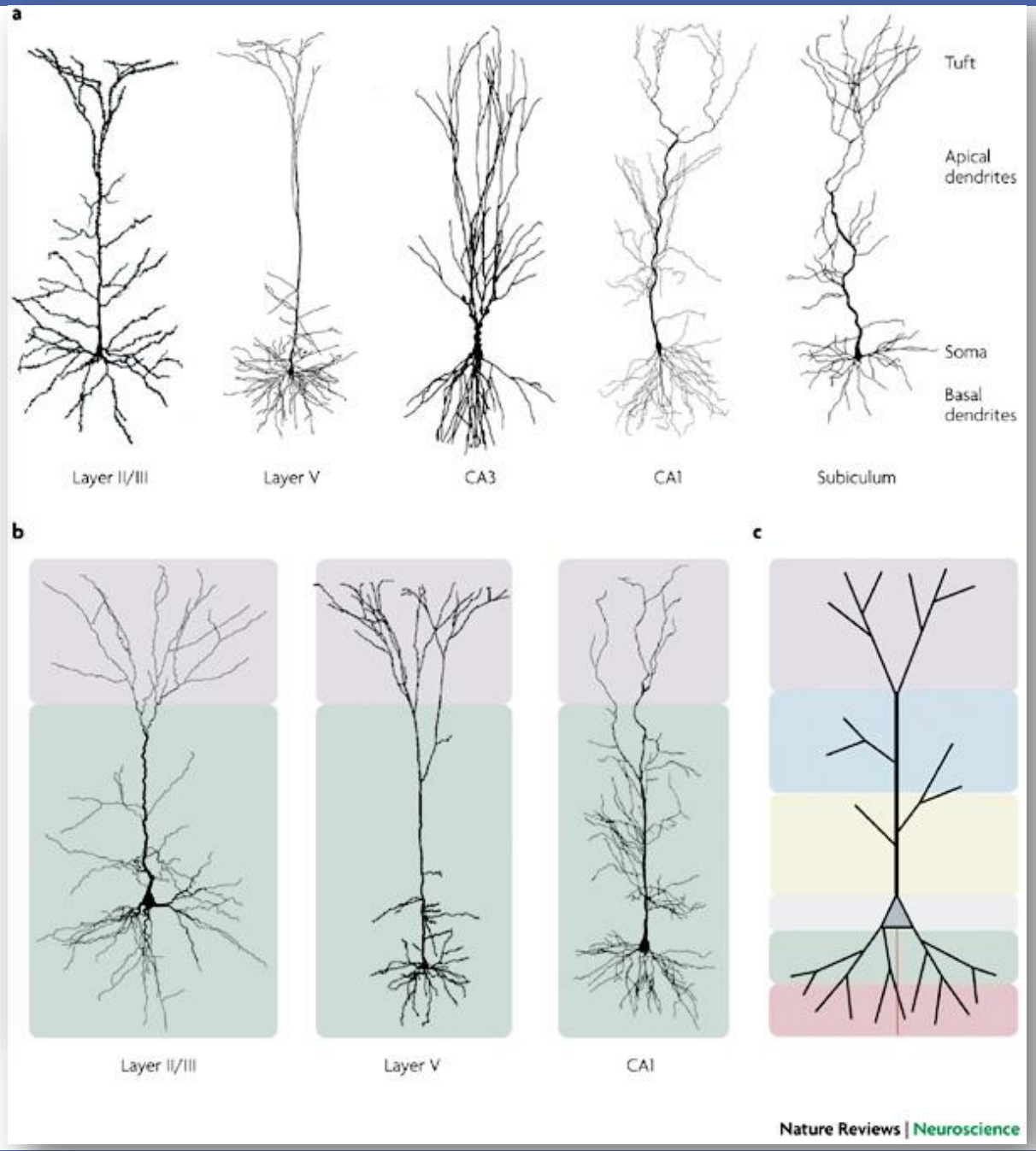
1. GENERATOR OF BRAIN WAVES

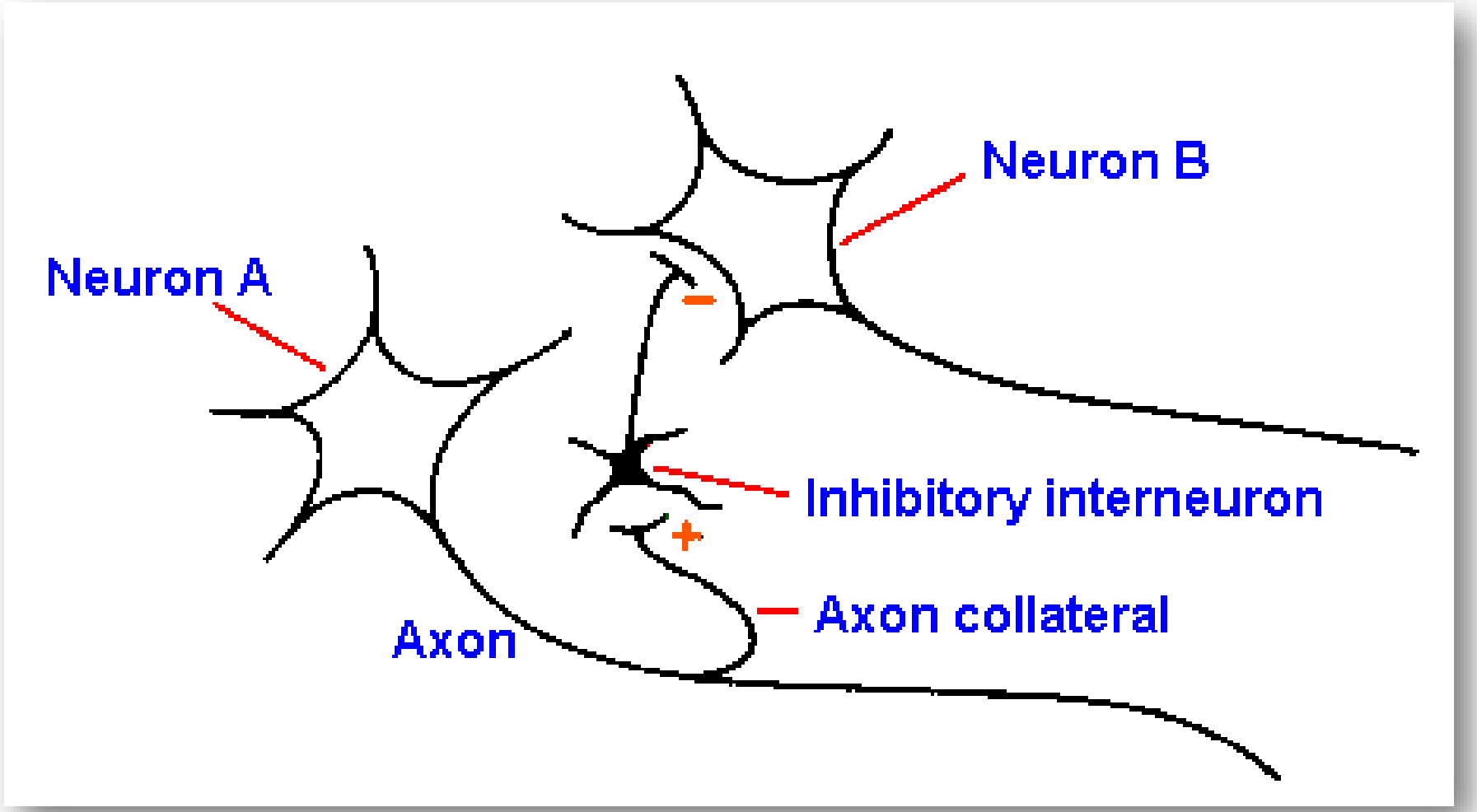
The generator of EEG

- **EEG** = summation of postsynaptic membrane potentials of the cortical neurons (**NOT** summation of action potentials)

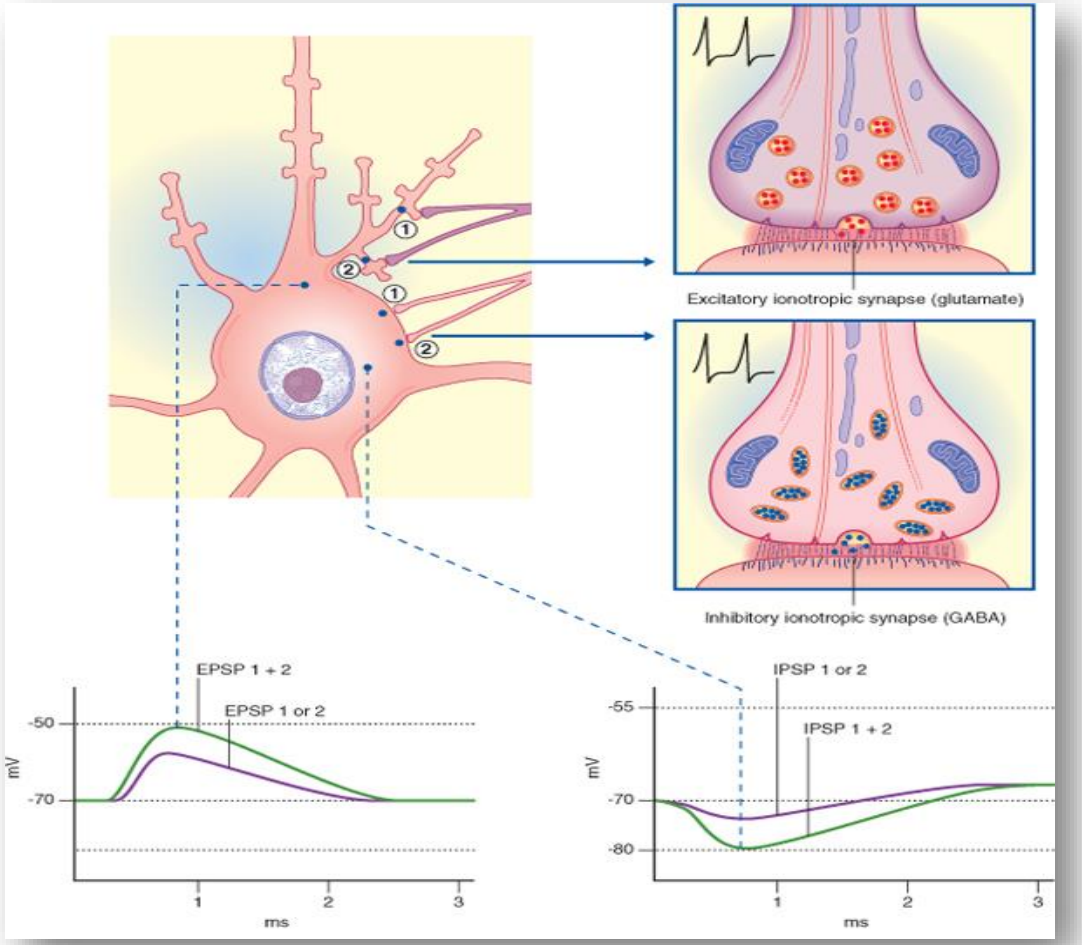
- Principal generators of EEG fields measured on surface of brain or at scalp are graded synaptic potentials **(EPSP, IPSP)** of the pyramidal neurons

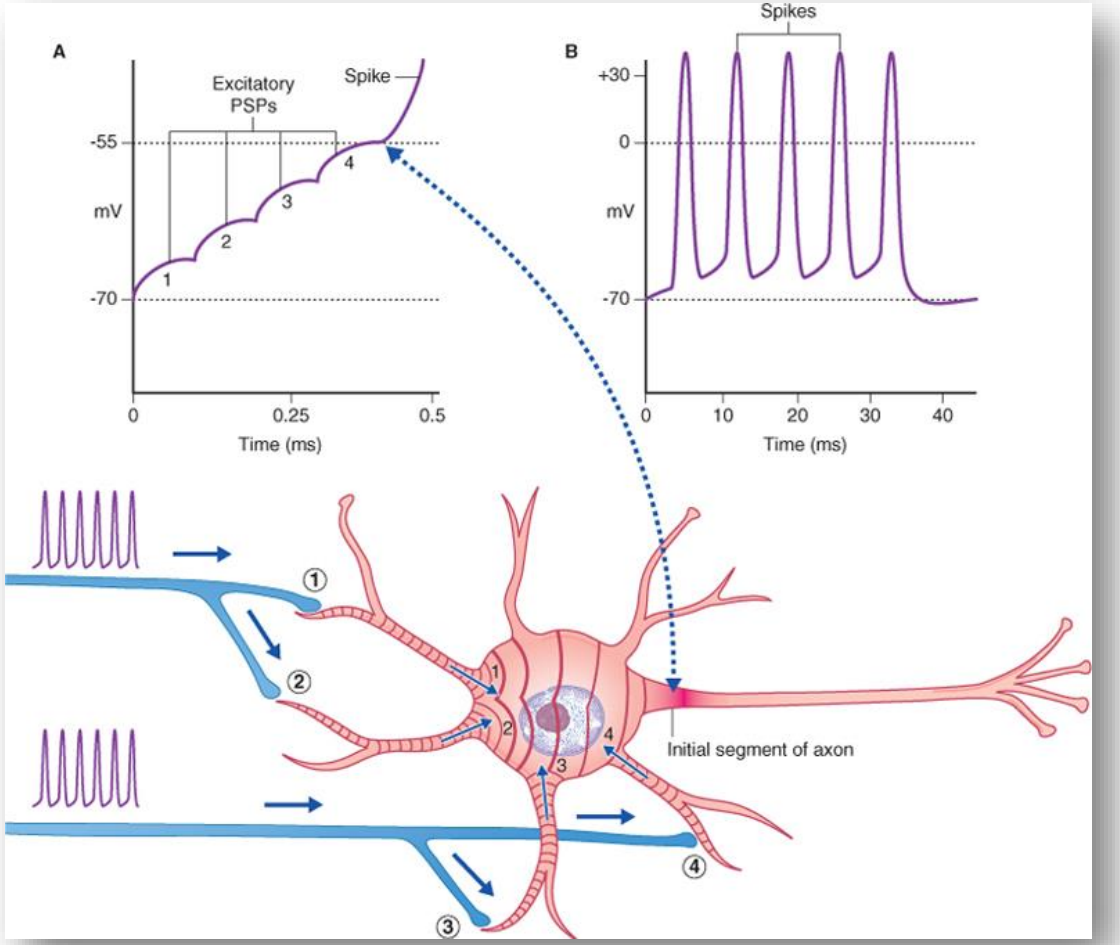

CORTEX
Axons and dendrites from various layers
I
II
III
IV
V
VI
To other parts of brain
Pyramidal cell
White matter
Descending nerve fibres


a
Tuft
Apical dendrites
Soma
Basal dendrites
Layer II/III
Layer V
CA3
CA1
Subiculum
b
c
Layer II/III
Layer V
CA1
Nature Reviews | Neuroscience


Neuron B
Neuron A
Inhibitory interneuron
Axon collateral
Axon

EPSP VS IPSP


Excitatory ionotropic synapse (glutamate)
Inhibitory ionotropic synapse (GABA)
EPSP 1 + 2
EPSP 1 or 2
IPSP 1 or 2
IPSP 1 + 2
mV
ms

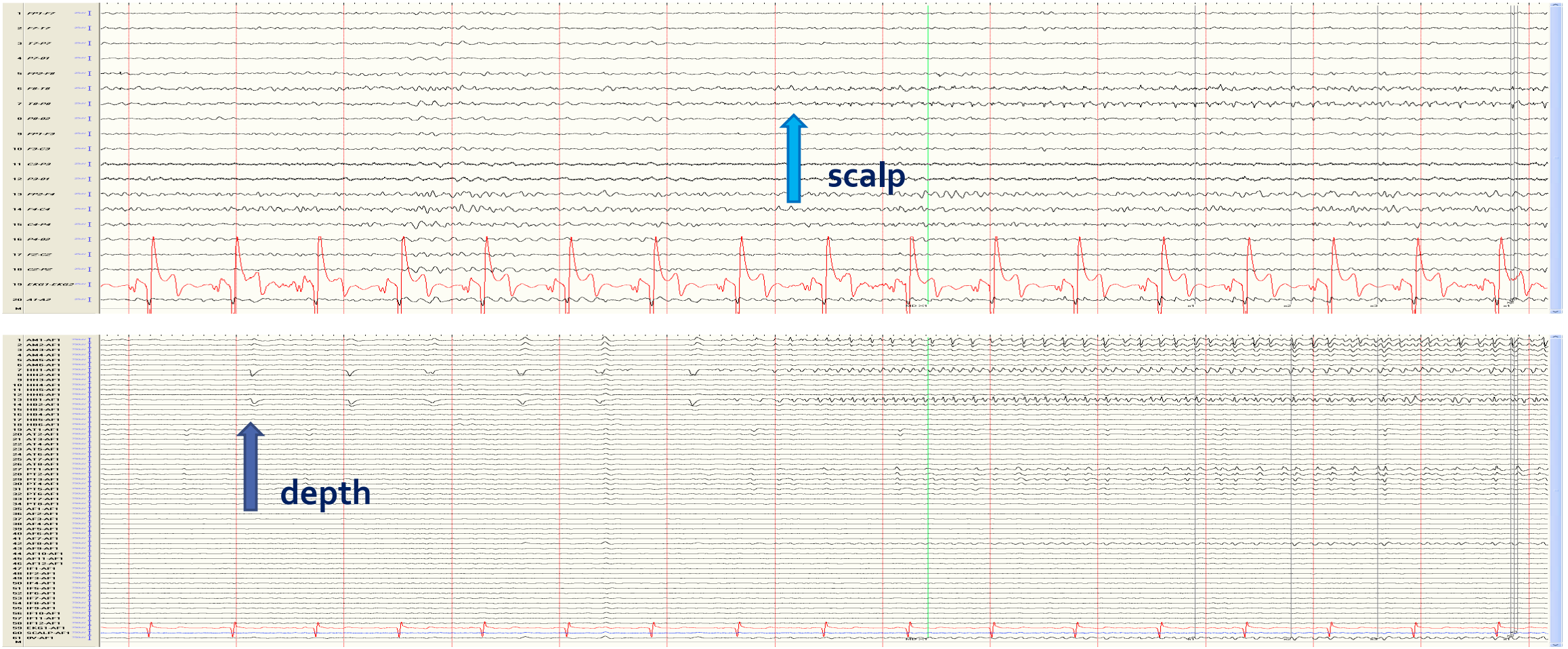

A
Excitatory PSPs
Spike
Time (ms)
B
Spikes
Time (ms)
mV
Initial segment of axon

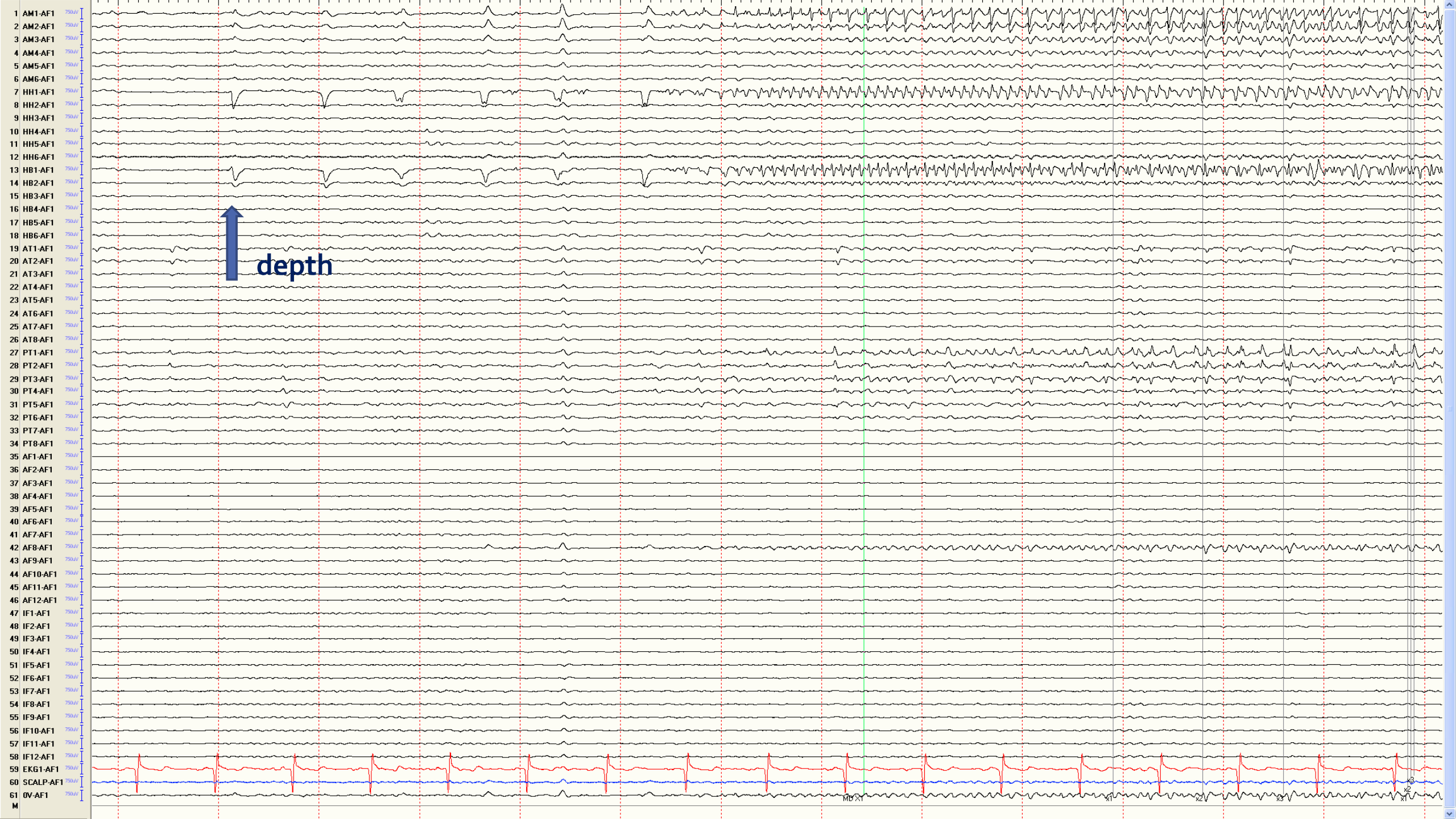
The generator of EEG

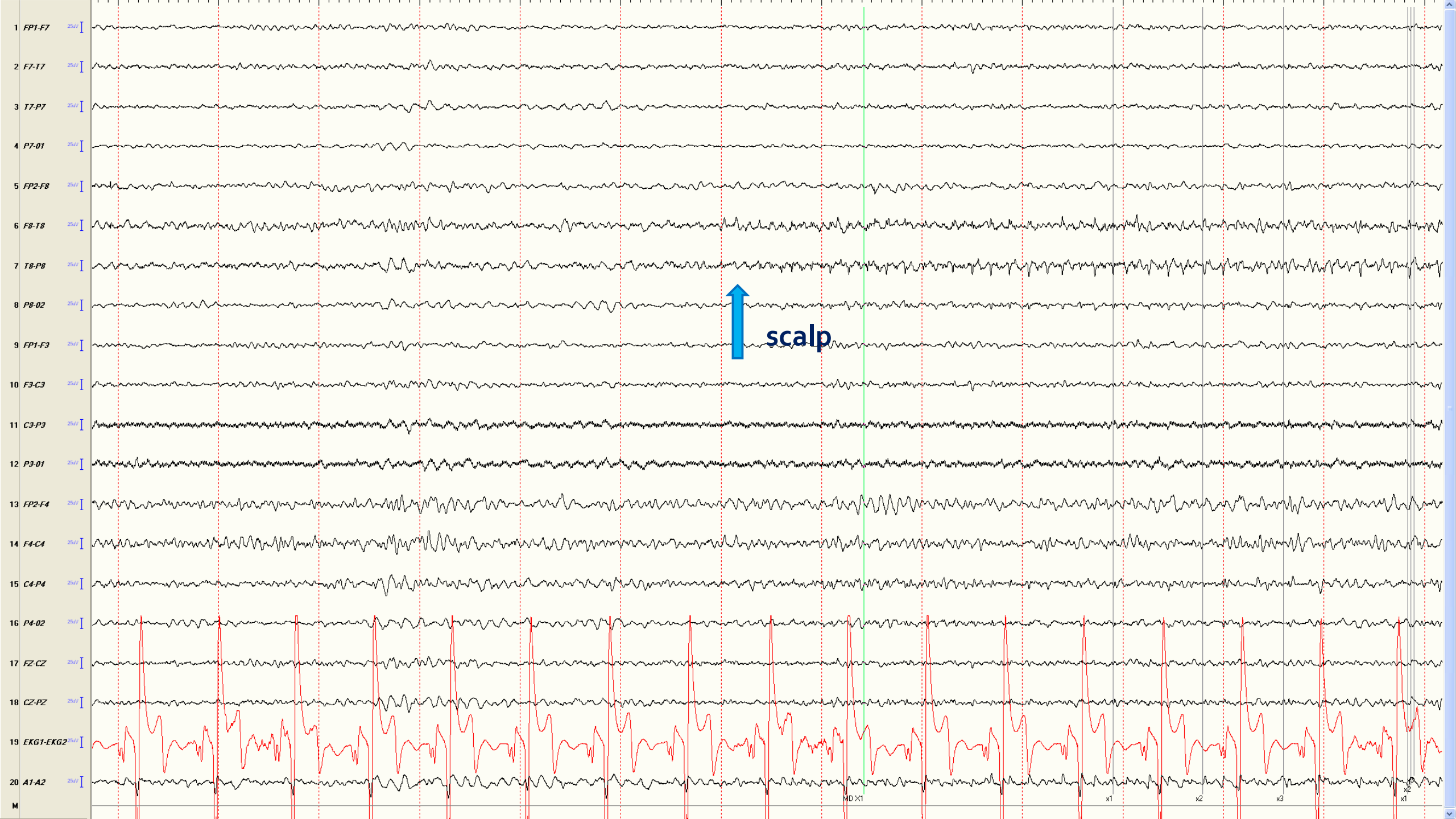
- A minimum cortical area of **6 cm^2** is needed to create visible EEG

- EEG signal represent the summated electrical activity generated by large population of neurons (10^5 or more), mainly from **cortical neuronal layers**

Simultaneous scalp and depth electrode recording




1 AM1-AF1
2 AM2-AF1
3 AM3-AF1
4 AM4-AF1
5 AM5-AF1
6 AM6-AF1
7 HH1-AF1
8 HH2-AF1
9 HH3-AF1
10 HH4-AF1
11 HH5-AF1
12 HH6-AF1
13 HB1-AF1
14 HB2-AF1
15 HB3-AF1
16 HB4-AF1
17 HB5-AF1
18 HB6-AF1
19 AT1-AF1
20 AT2-AF1
21 AT3-AF1
22 AT4-AF1
23 AT5-AF1
24 AT6-AF1
25 AT7-AF1
26 AT8-AF1
27 PT1-AF1
28 PT2-AF1
29 PT3-AF1
30 PT4-AF1
31 PT5-AF1
32 PT6-AF1
33 PT7-AF1
34 PT8-AF1
35 AF1-AF1
36 AF2-AF1
37 AF3-AF1
38 AF4-AF1
39 AF5-AF1
40 AF6-AF1
41 AF7-AF1
42 AF8-AF1
43 AF9-AF1
44 AF10-AF1
45 AF11-AF1
46 AF12-AF1
47 IF1-AF1
48 IF2-AF1
49 IF3-AF1
50 IF4-AF1
51 IF5-AF1
52 IF6-AF1
53 IF7-AF1
54 IF8-AF1
55 IF9-AF1
56 IF10-AF1
57 IF11-AF1
58 IF12-AF1
59 EKG1-AF1
60 SCALP-AF1
61 0V-AF1
M
depth


1 FP1-F7
2 F7-T7
3 T7-P7
4 P7-01
5 FP2-F8
6 F8-T8
7 T8-P8
8 P8-02
9 FP1-F3
10 F3-C3
11 C3-P3
12 P3-01
13 FP2-F4
14 F4-C4
15 C4-P4
16 P4-02
17 FZ-CZ
18 CZ-PZ
19 EKG1-EKG2
20 A1-A2
M
25uV
scalp
MD X1
x1
x2
x3
x2
x1

Pyramidal cell as a dipole

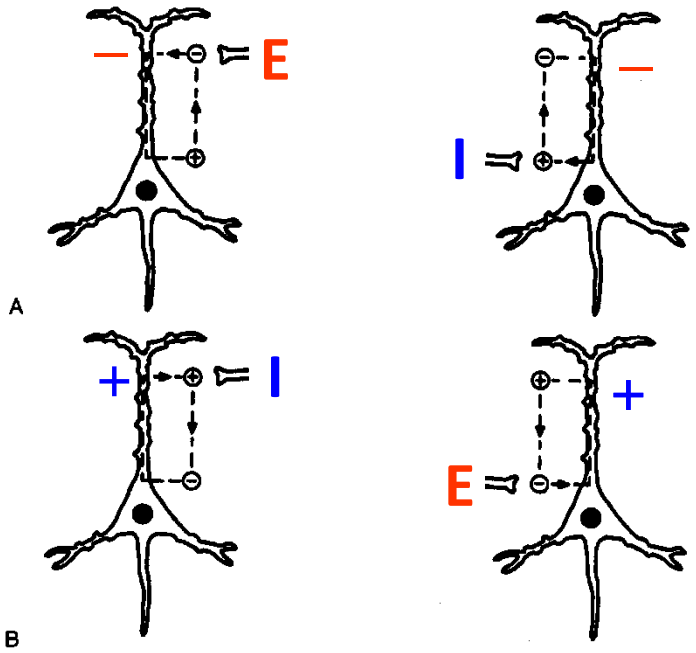


FIG. 4.1. A: A pyramidal cell dipole that is surface negative and depth positive can be produced either by excitatory synaptic input at the surface or by inhibitory synaptic input in the depths. **B:** Conversely, a pyramidal cell dipole that is surface positive and depth negative can be produced by inhibitory activity at the surface-positive end of the pyramidal cell or excitatory activity at the negative end. See also Fig. 4.4.

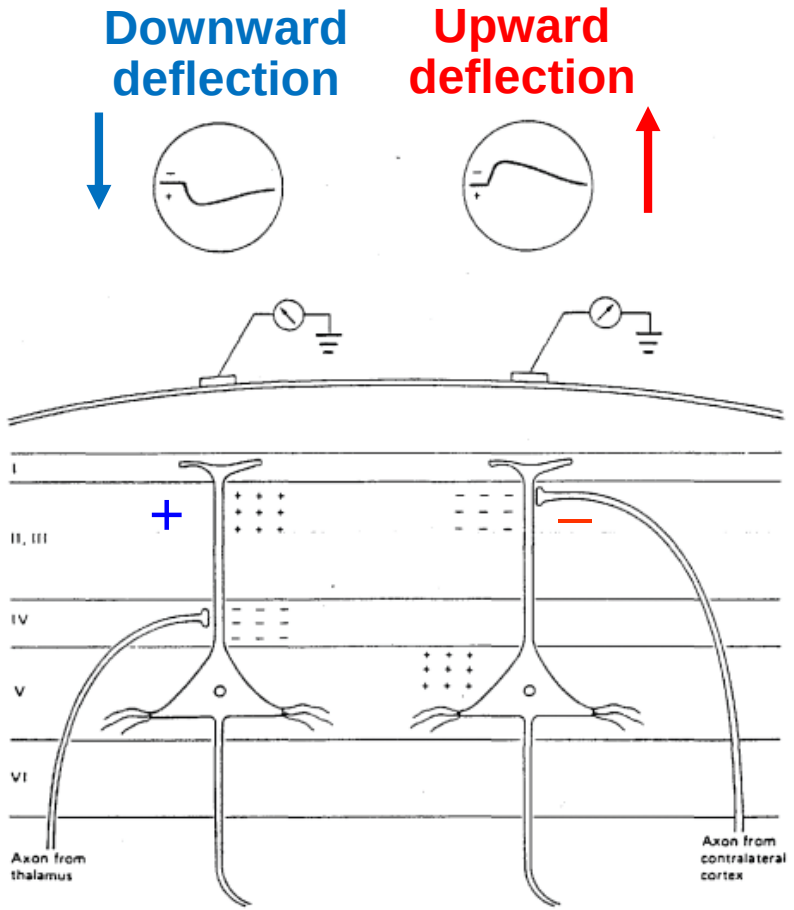
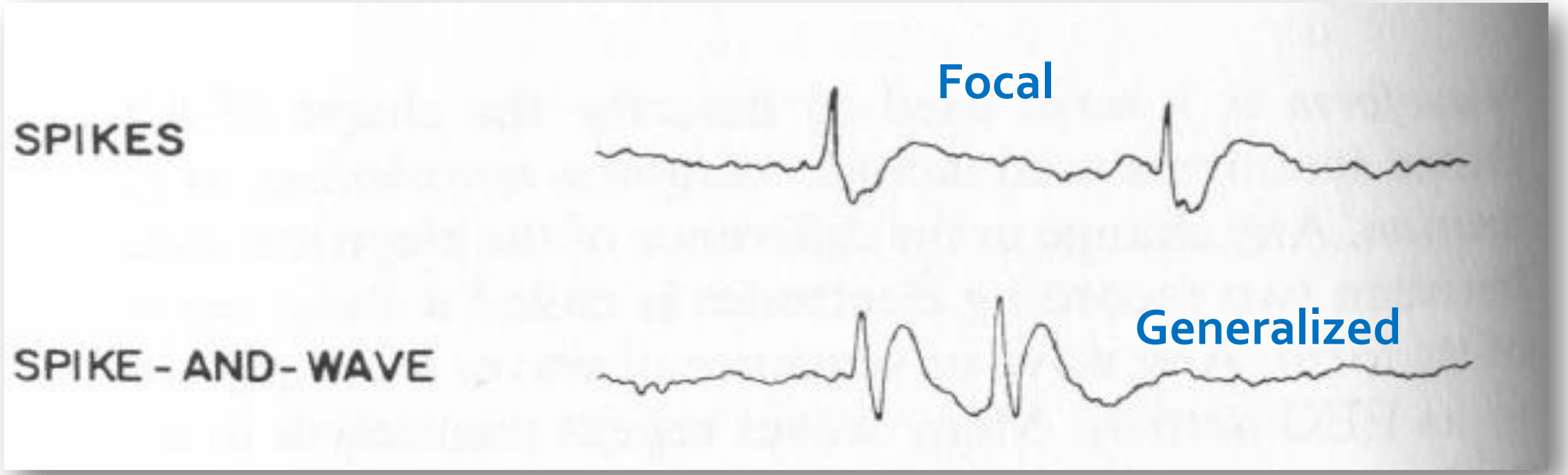
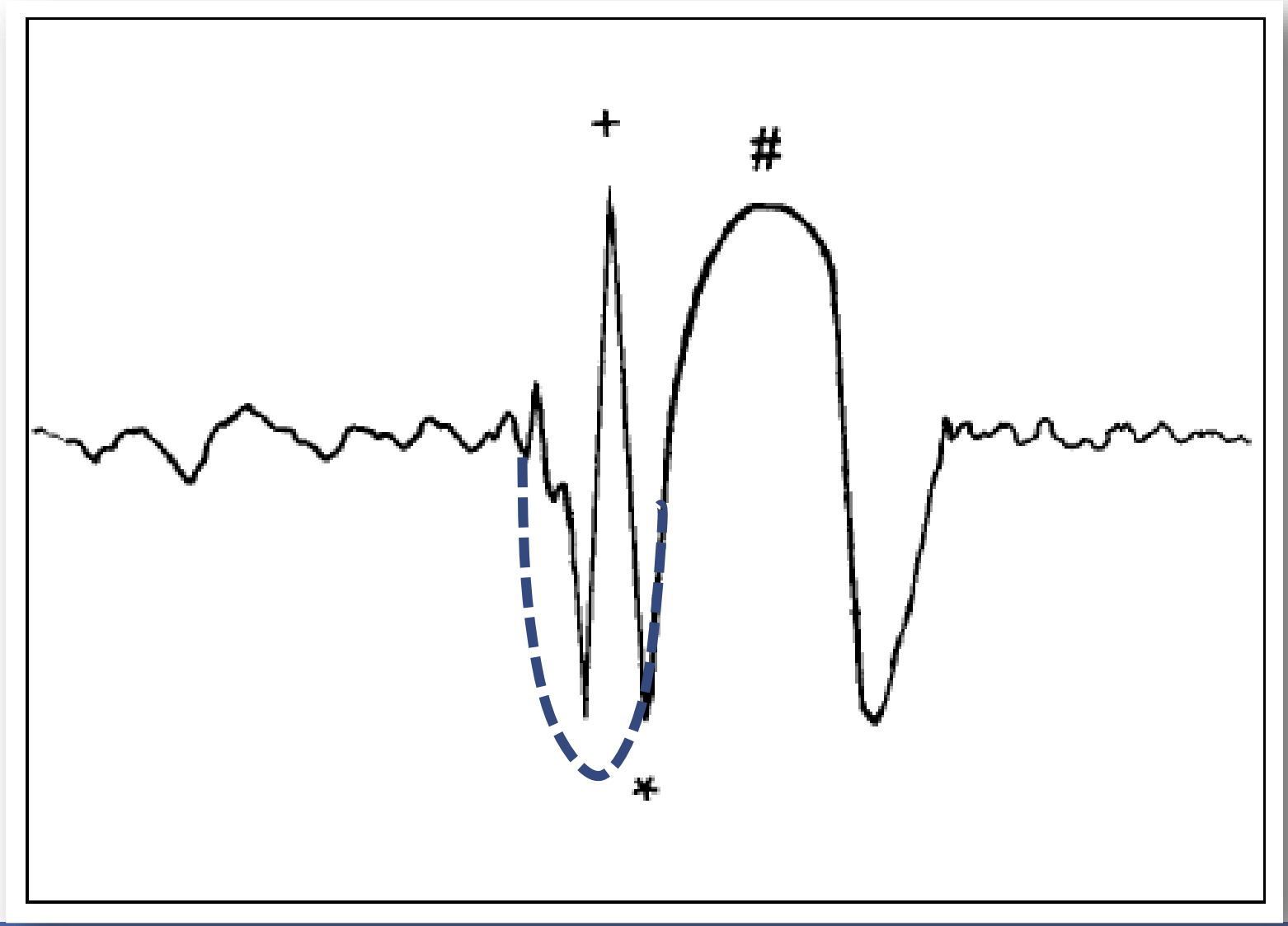


FIGURE 2. Generation of extracellular voltage fields from graded synaptic activity (from Martin, 1991). Relationship between polarity of surface potentials and site of dendritic postsynaptic potentials.

Large vertically oriented pyramidal neurons in cortex layers III, V and VI

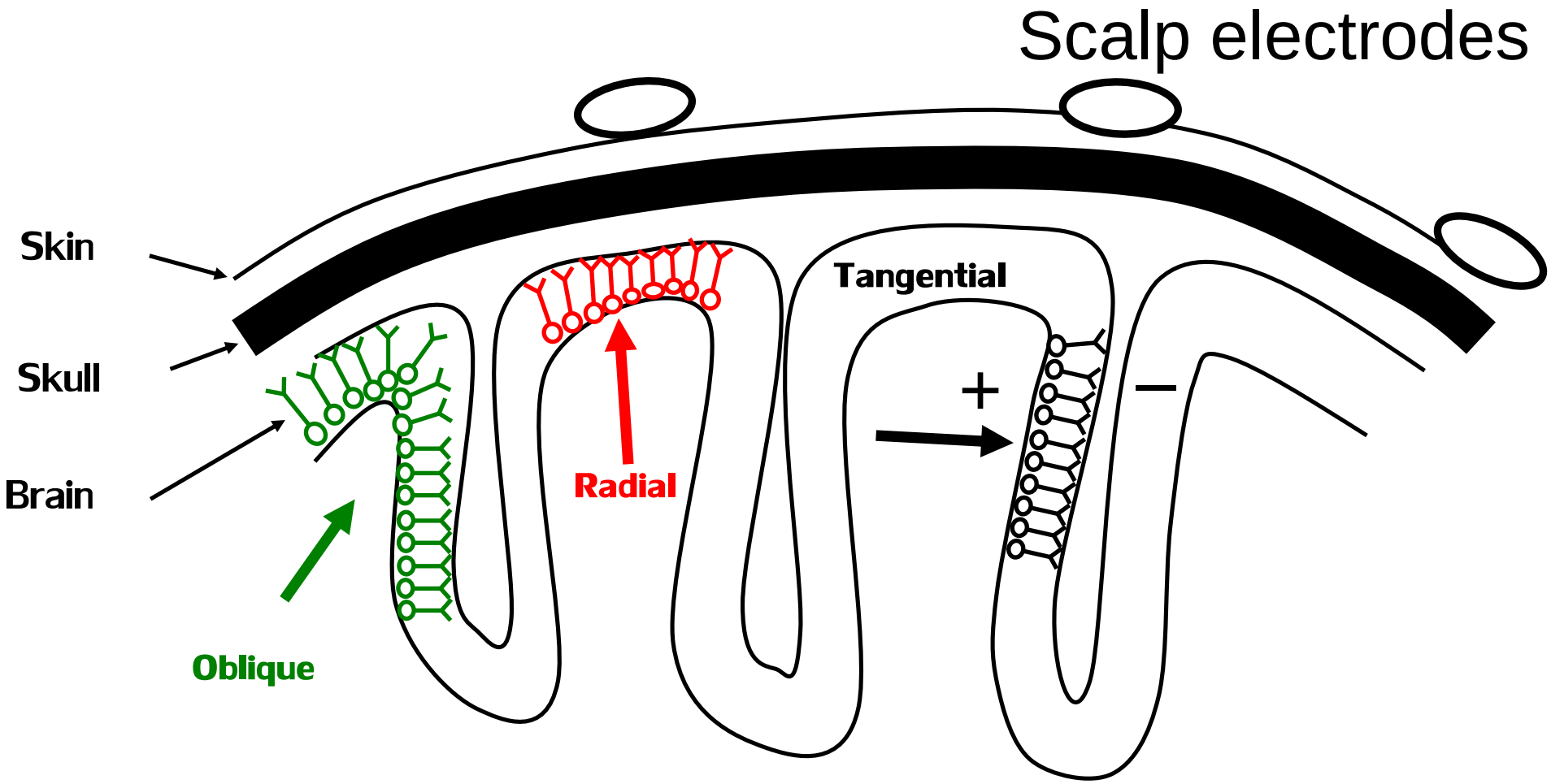

SPIKES
Focal
SPIKE - AND - WAVE
Generalized

Generalized spike-and-wave epileptiform discharges

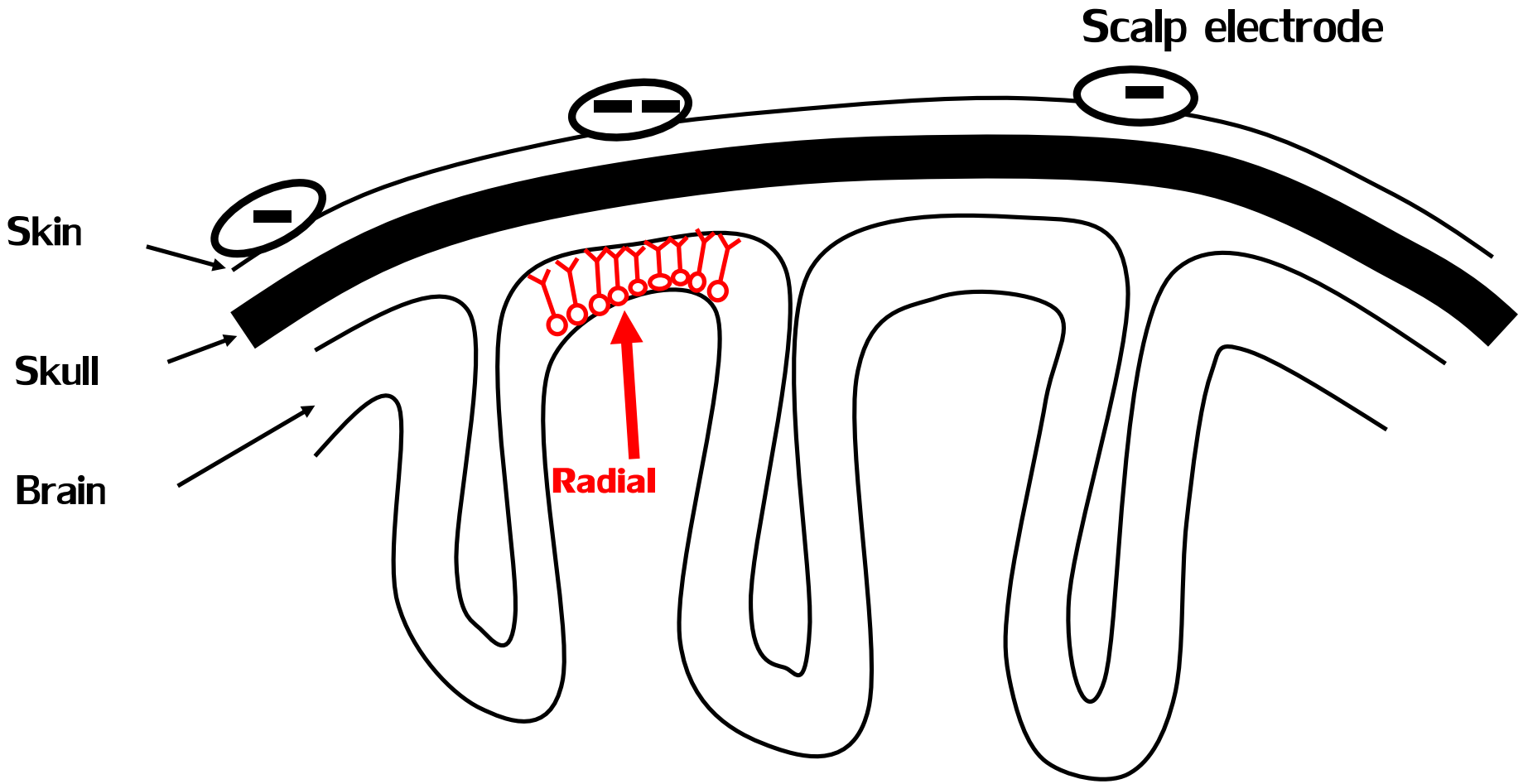


2. EEG POLARITY

Variety of neuronal positions

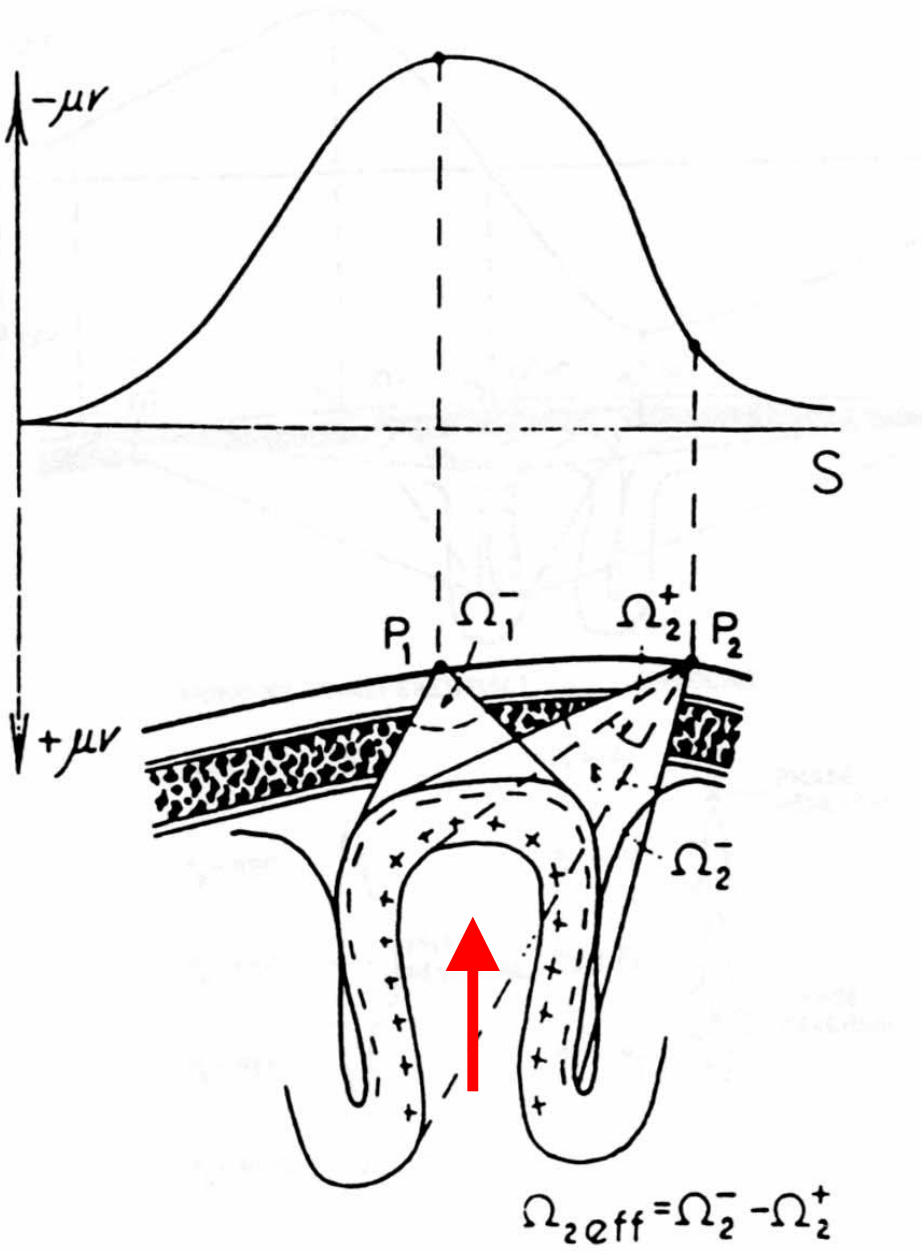


Neuronal Positions:
Radial dipole



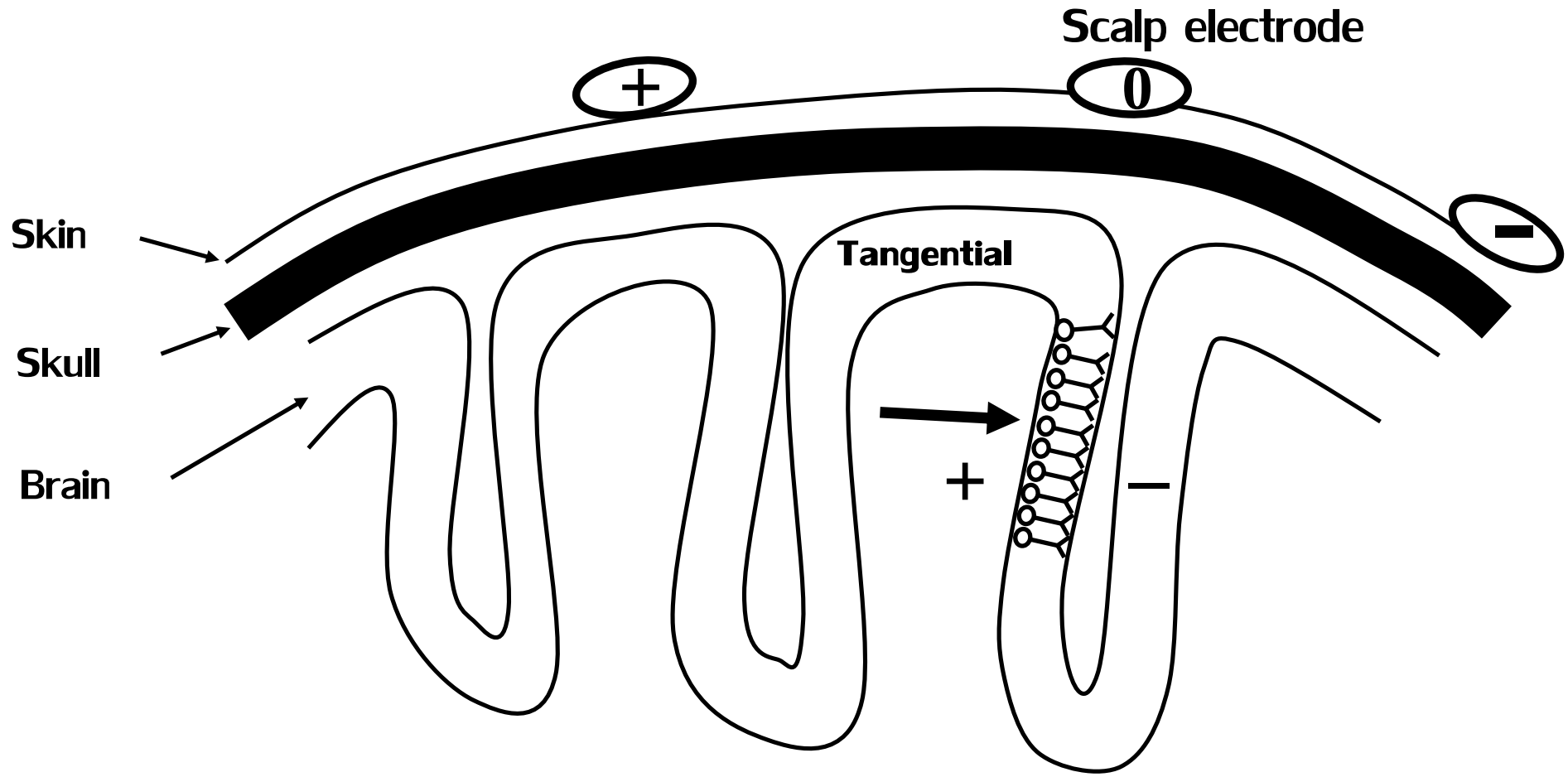
Radial dipole (vertical)

Bell-shaped EEG voltage plot

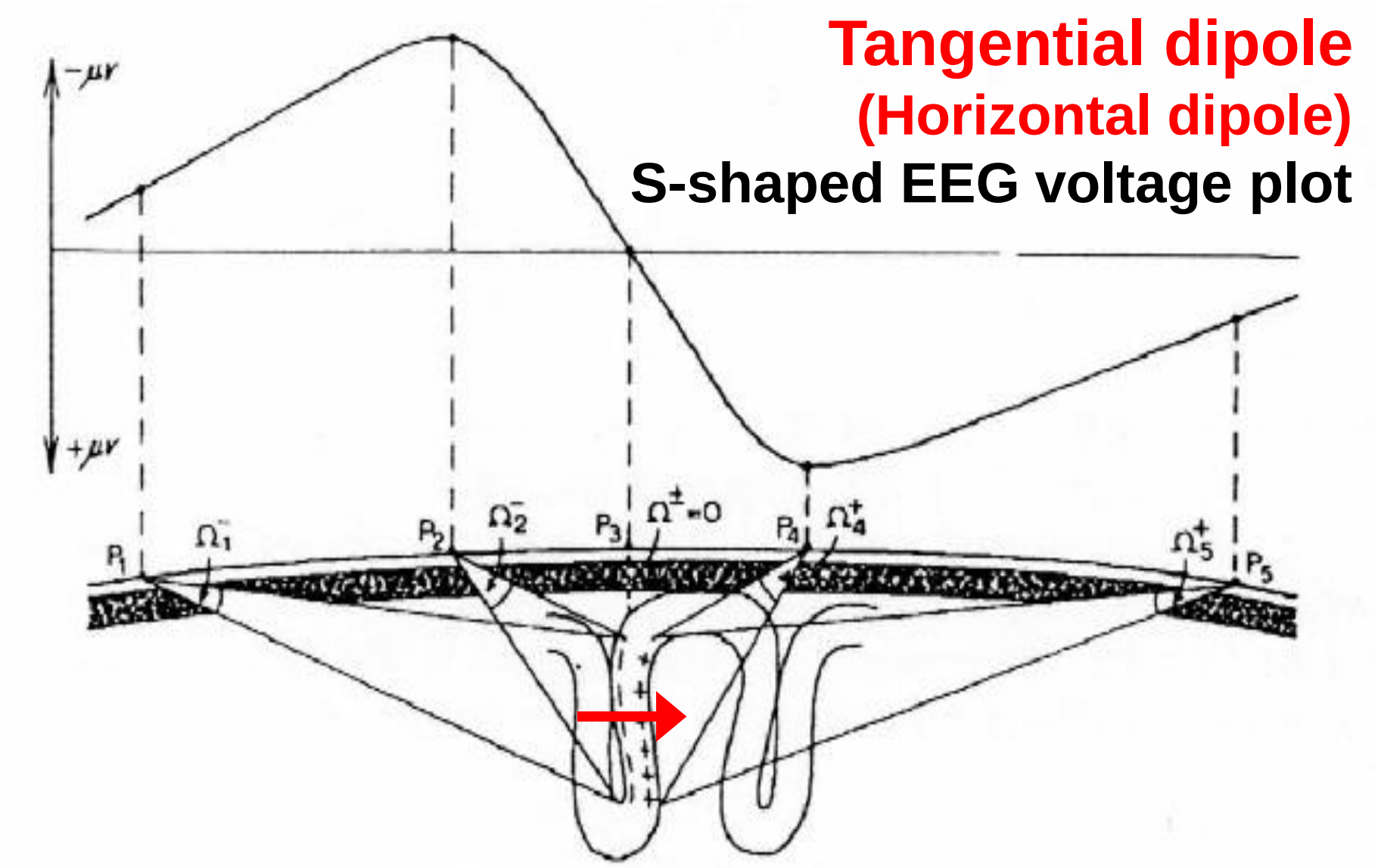


(Gloor 85)

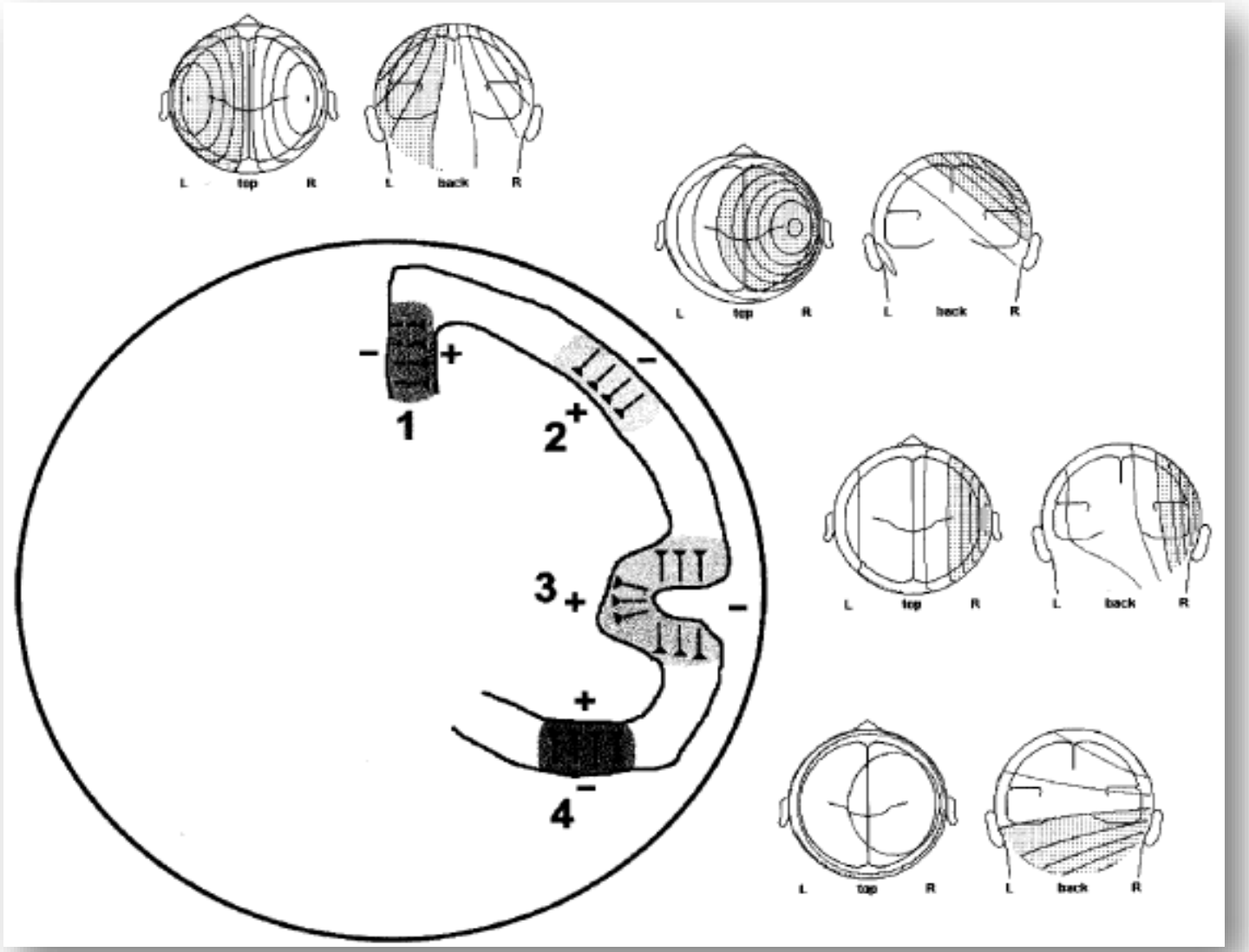
Neuronal Positions:
Tangential dipole



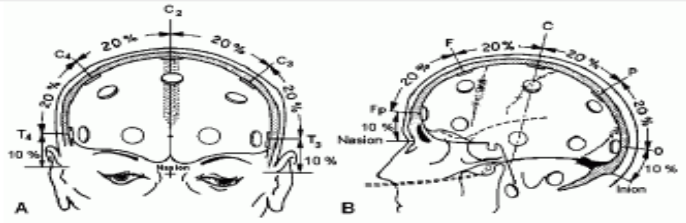
Tangential dipole
(Horizontal dipole)
S-shaped EEG voltage plot



Dipoles in different brain areas



3. EEG MONTAGES



Dr. H. Jasper

The 10-20 System of Head Measurement and Electrode Placement

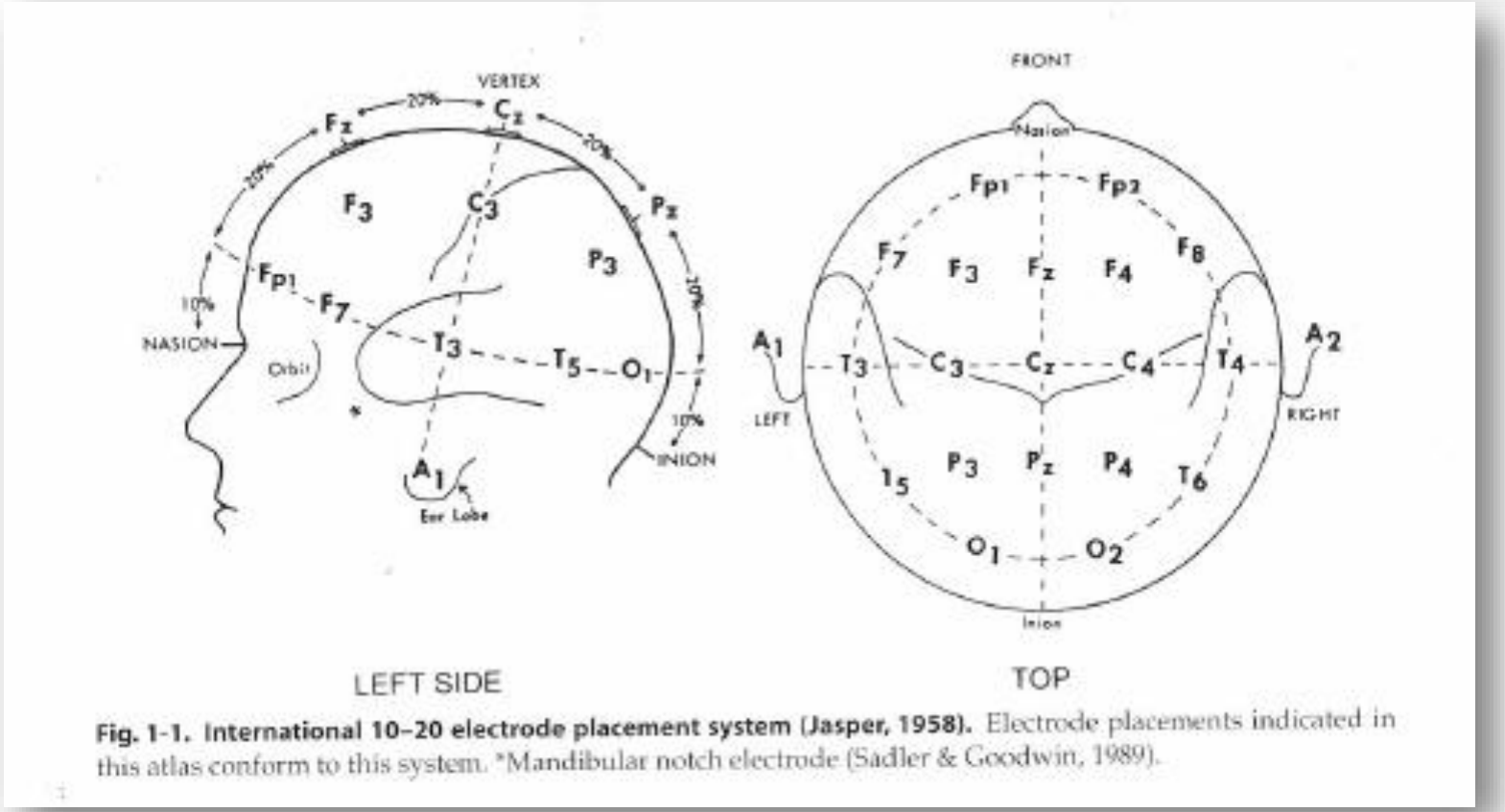
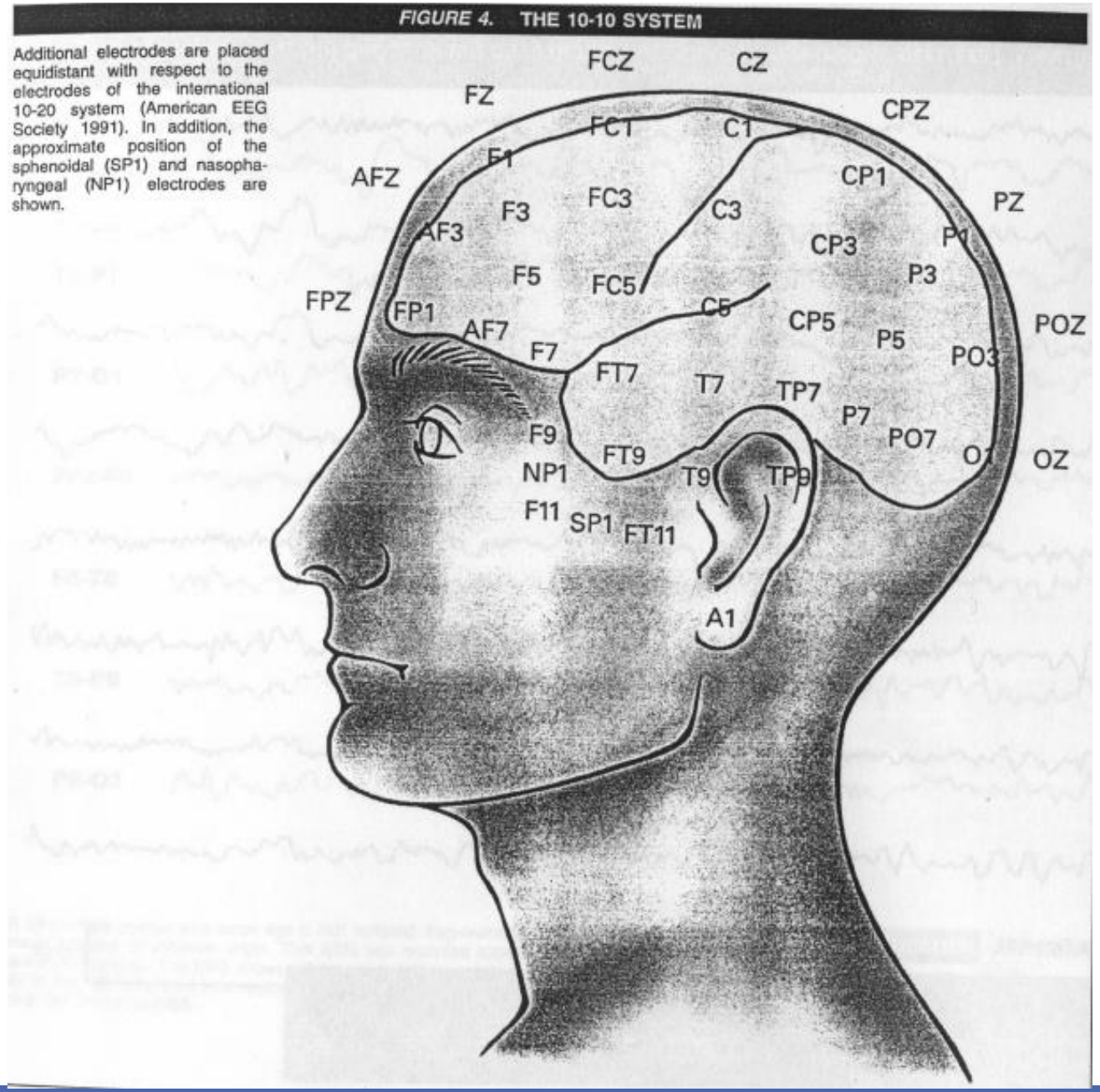


Fig. 1-1. International 10–20 electrode placement system (Jasper, 1958). Electrode placements indicated in this atlas conform to this system. *Mandibular notch electrode (Sadler & Goodwin, 1989).



10-10 system

Odd number: left hemisphere
Even number: right hemisphere

F = Frontal
Fp = Frontopolar
T = Temporal
C = Central
P = Parietal
O = Occipital
Cz = midline central
A = Ear
SP = sphenoid

Graphic representation of difference in voltage between two different cerebral locations plotted over time

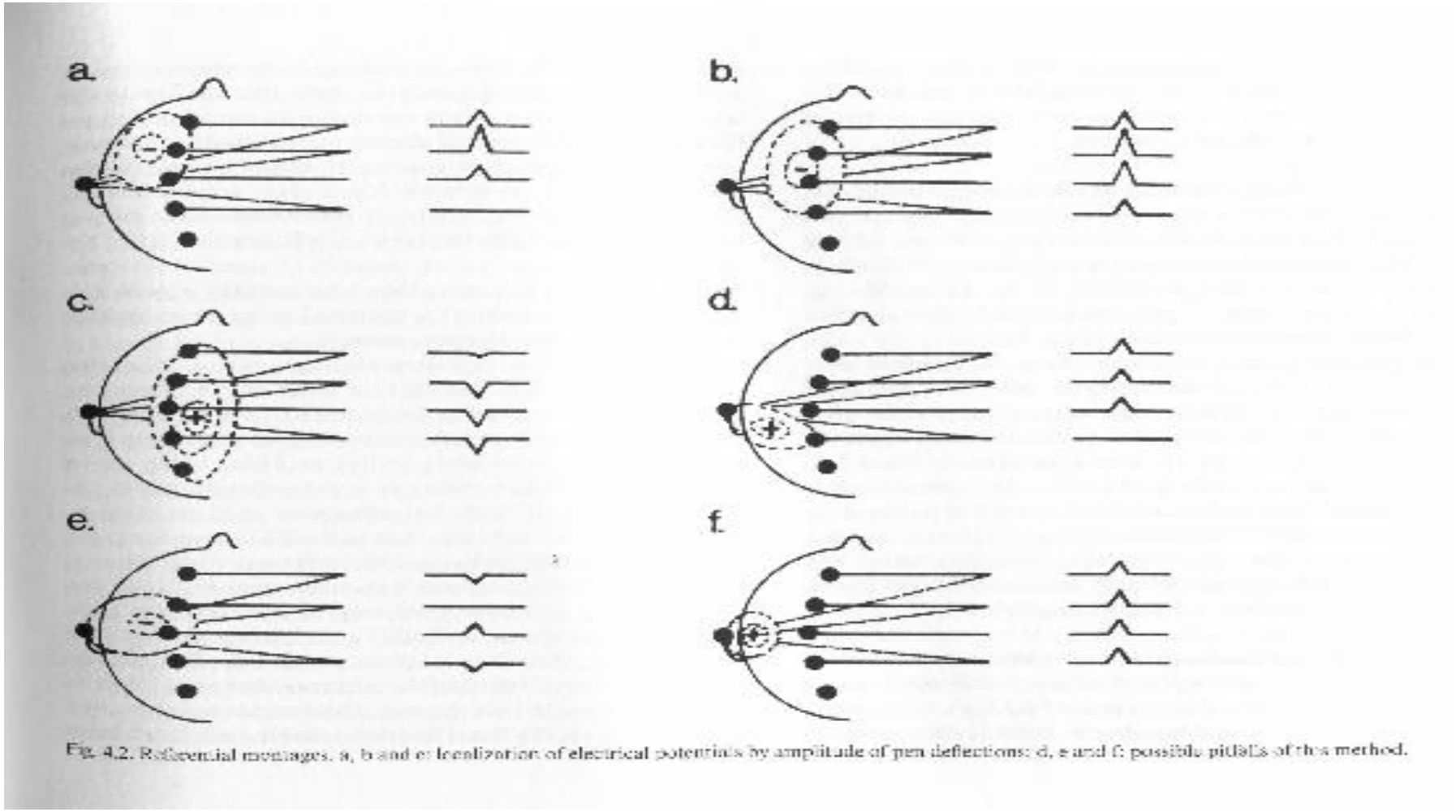


Fig. 4.2. Referential montages: a, b and c: localization of electrical potentials by amplitude of pen deflections: d, e and f: possible pitfalls of this method.

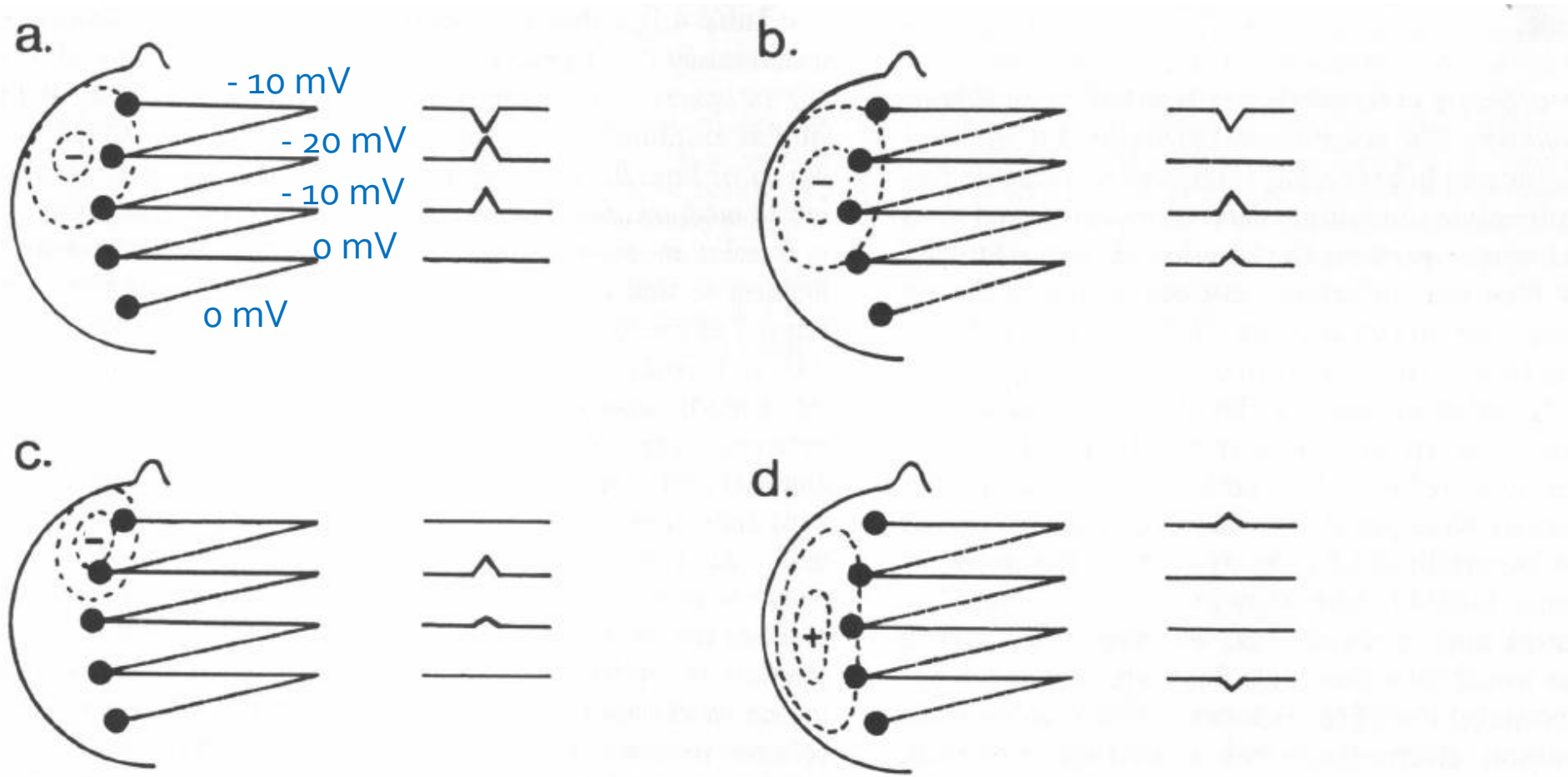
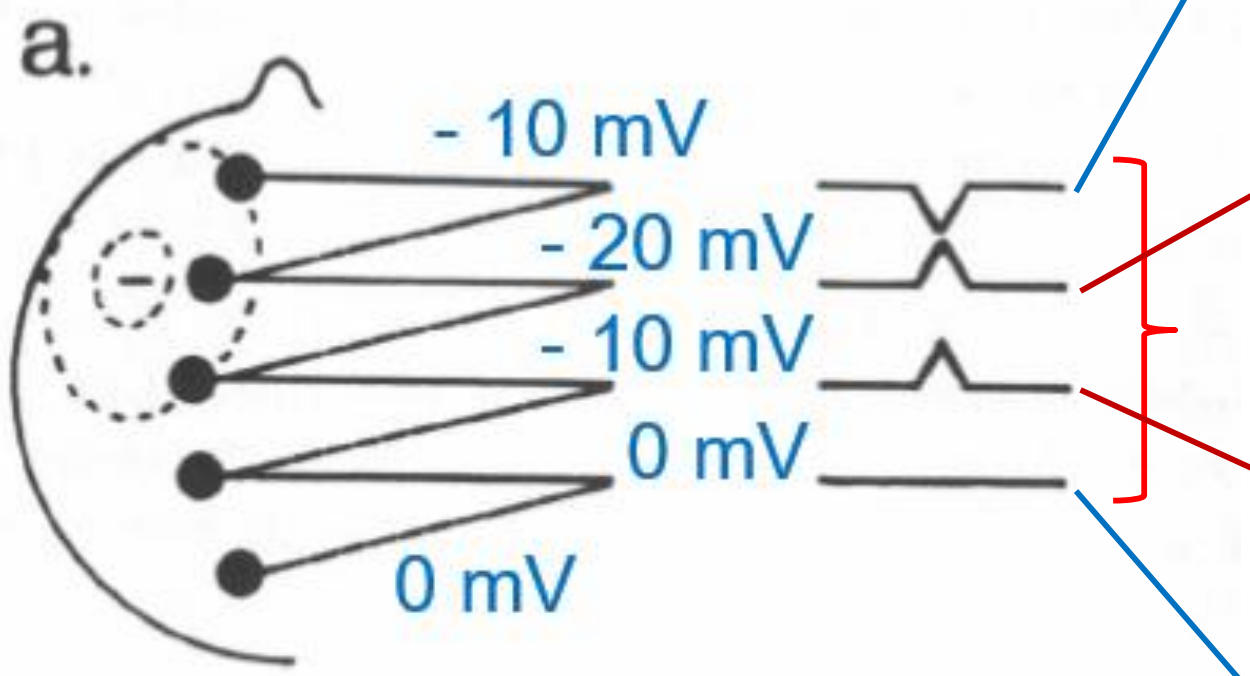


Fig. 4.1. Bipolar montages. a and b: localization of electrical potentials on the scalp by phase reversal; c and d: possible pitfalls of this method.

“Differential amplification”



- 10 – (-20) = -10 + 20 = + 10 mV

- 20 – (-10) = -20 + 10 = - 10 mV

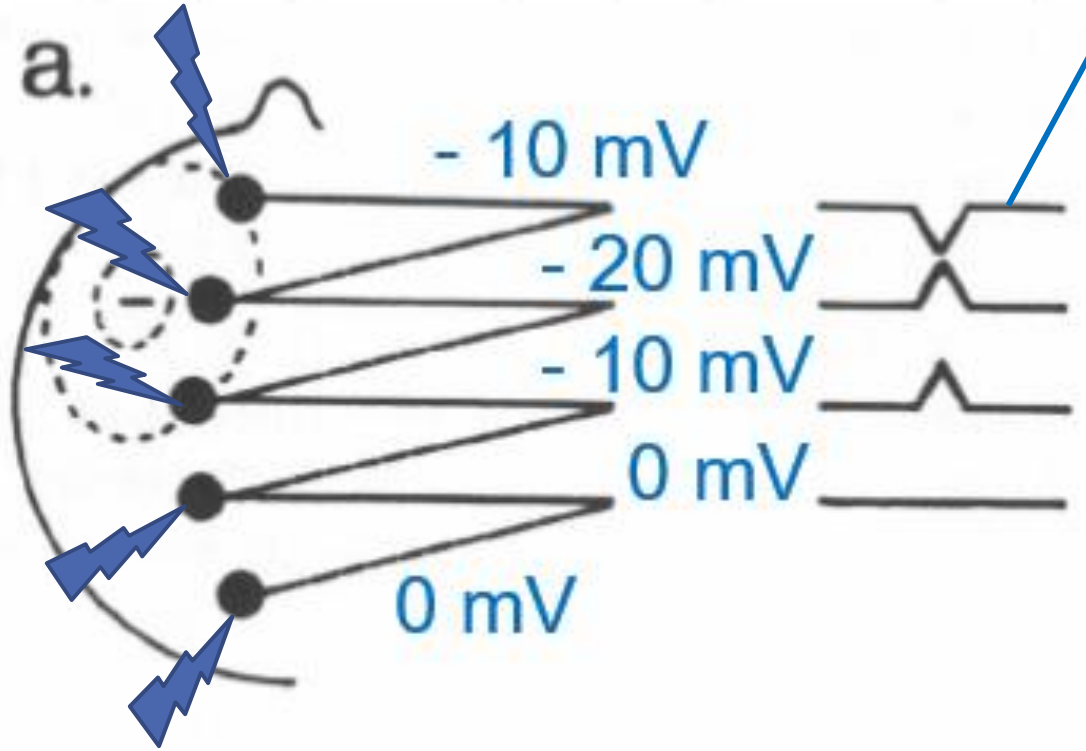
Potential field

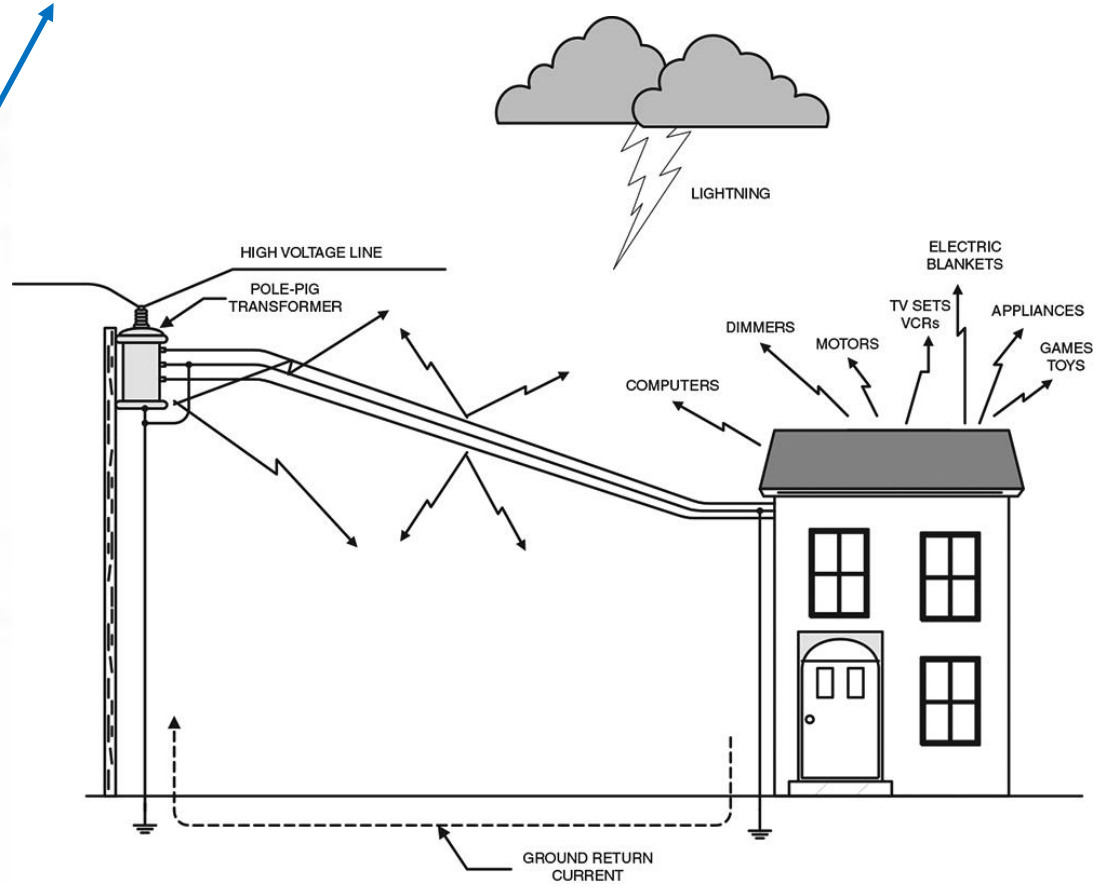
- 10 – 0 = - 10 mV

0 – 0 = 0 mV

“Common mode rejection concept”

- 10 – (-20) = -10 + 20 = + 10 mV



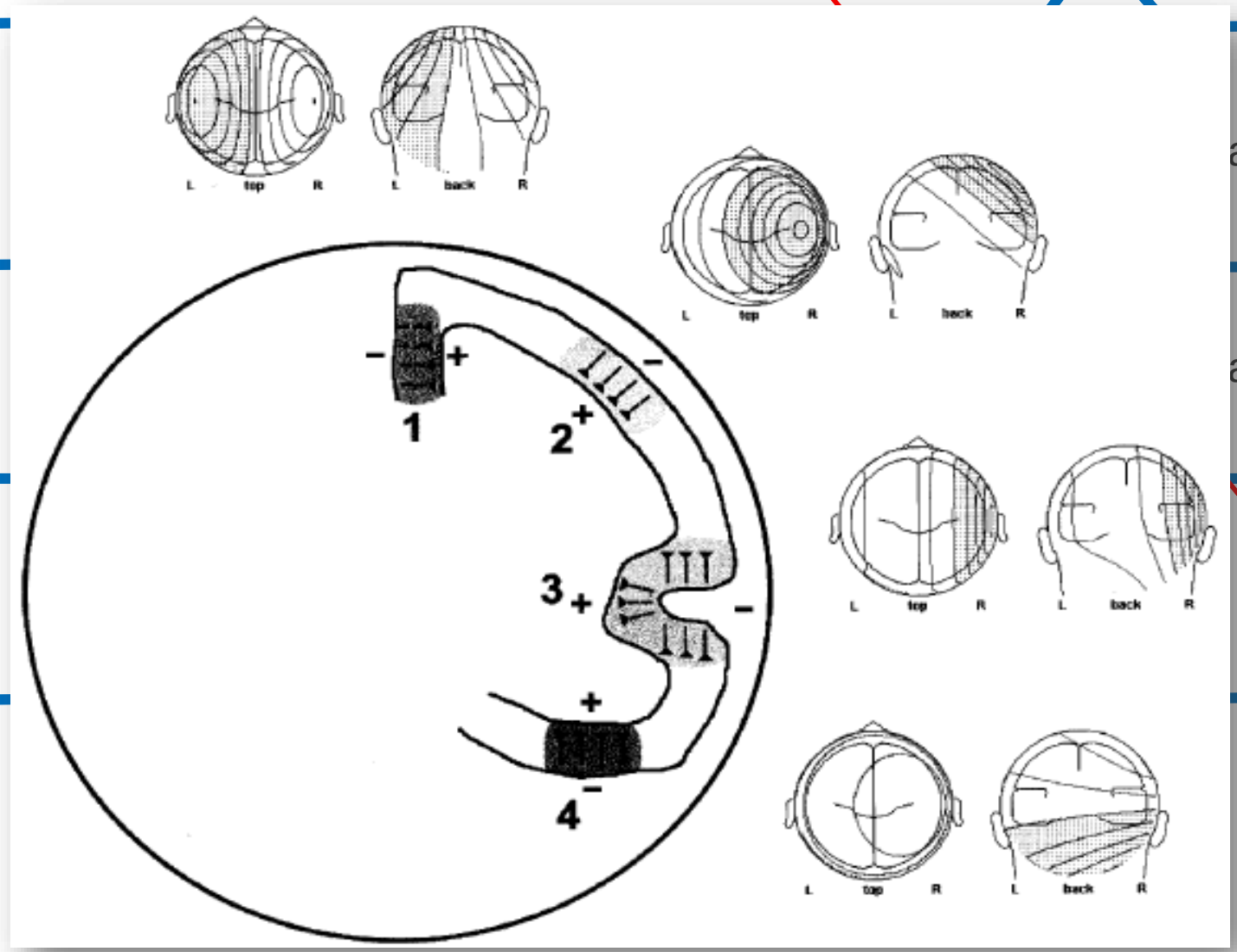


Channel		Negative phase reversal	Positive phase reversal
1	Fp1 – F7		
		Max negative at F7	Max positive at F7
2	F7 – T3		
3	T3 – T5		
4	T5 – O1		

	Channel
1	Fp1 – F7
2	F7 – T3
3	T3 – T5
4	T5 – O1

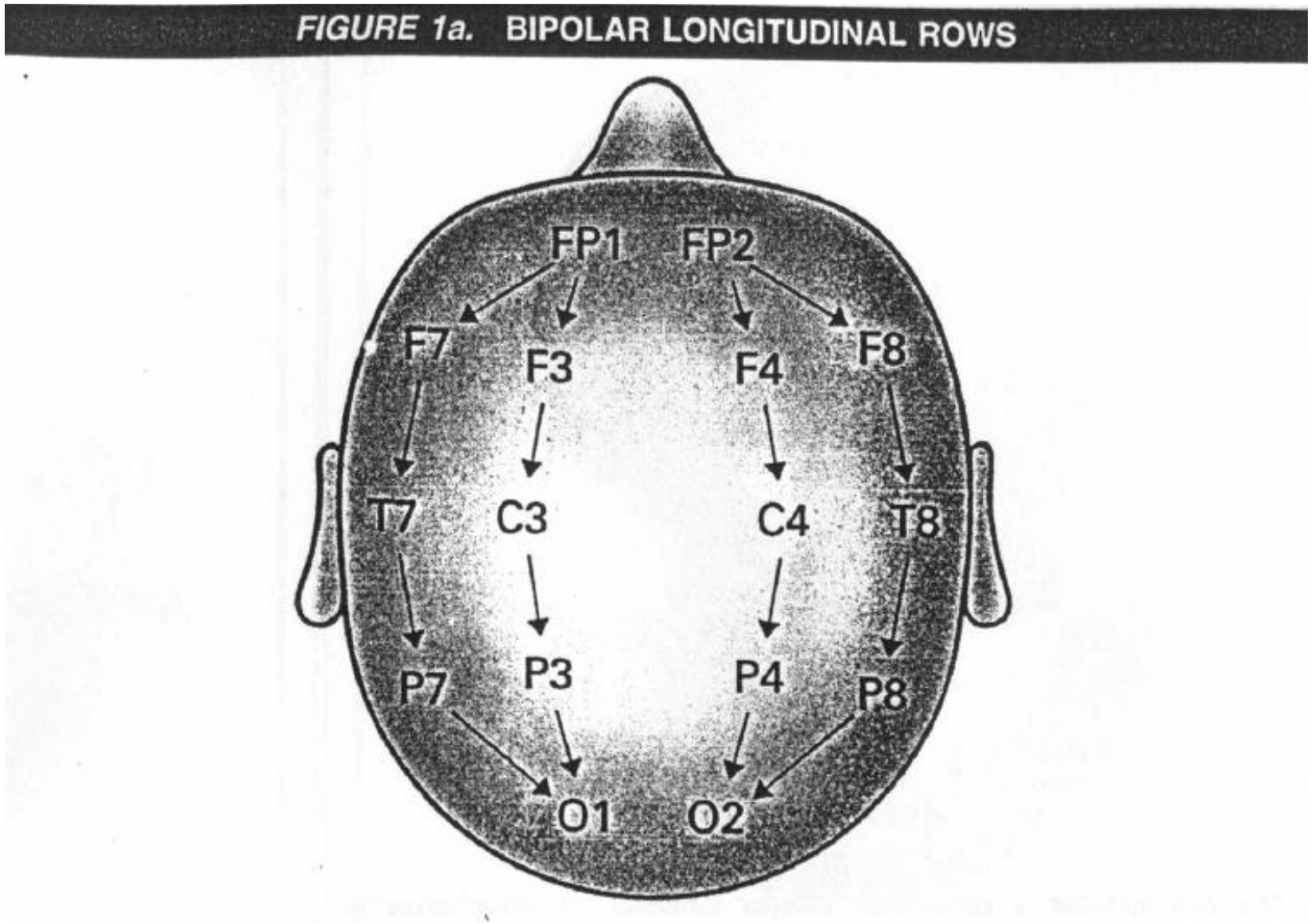
Negative phase reversal

Double phase reversal



ax **positive** at F7

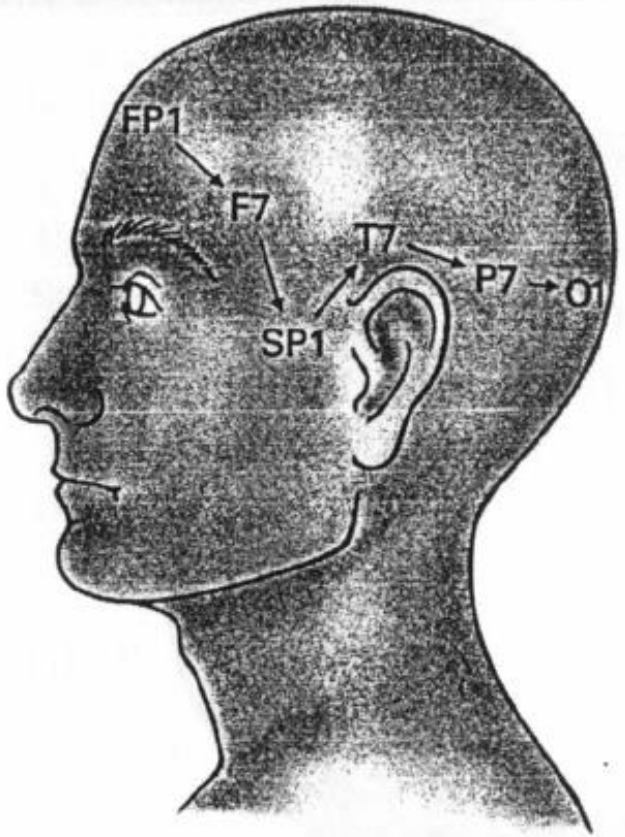
ax **negative** at F7



Montage

1) Bipolar montage
2) Referential montage

FIGURE 1b. BIPOLAR TEMPORAL LONGITUDINAL ROW



This row includes a sphenoidal, anterior temporal, or nasopharyngeal electrode. It is frequently used in this atlas.

FIGURE 1c. BIPOLAR TRANSVERSE ROWS

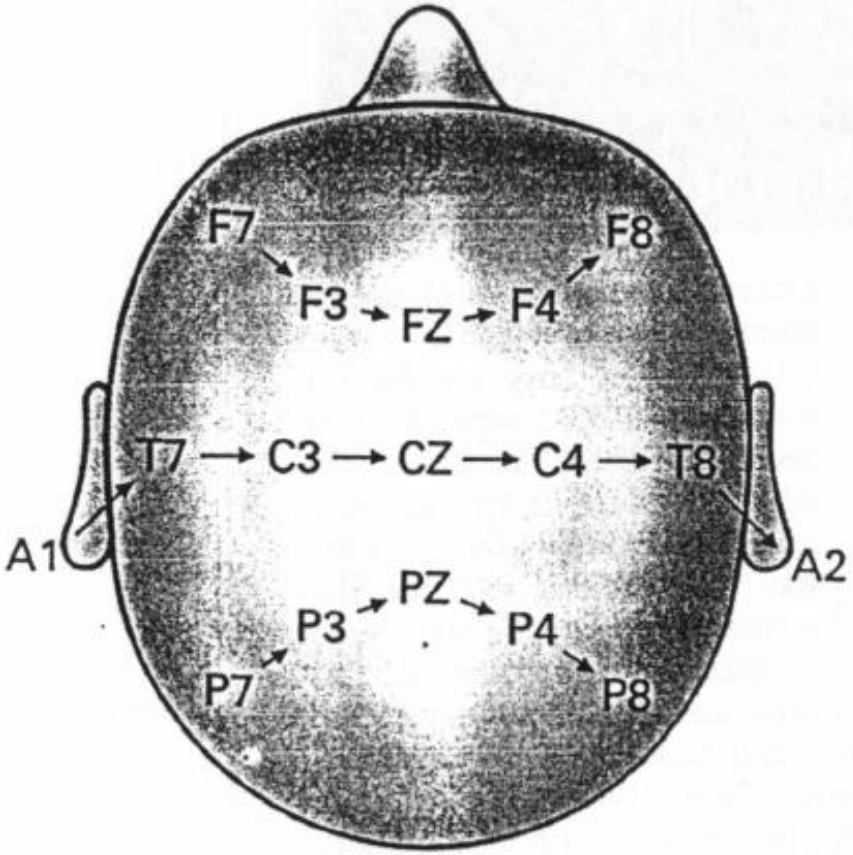


FIGURE 2a. CZ REFERENCE MONTAGE

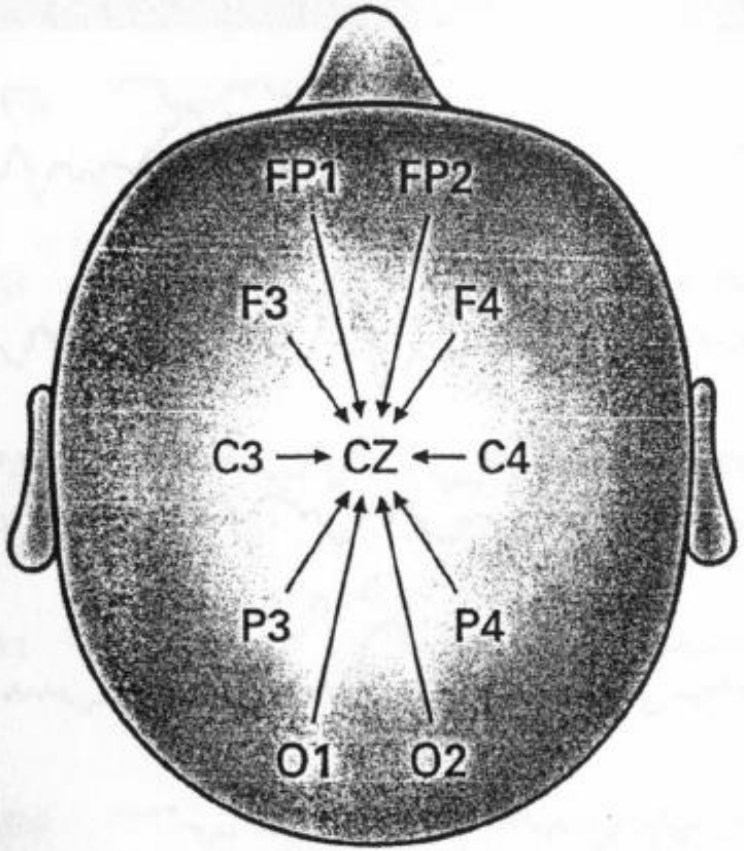
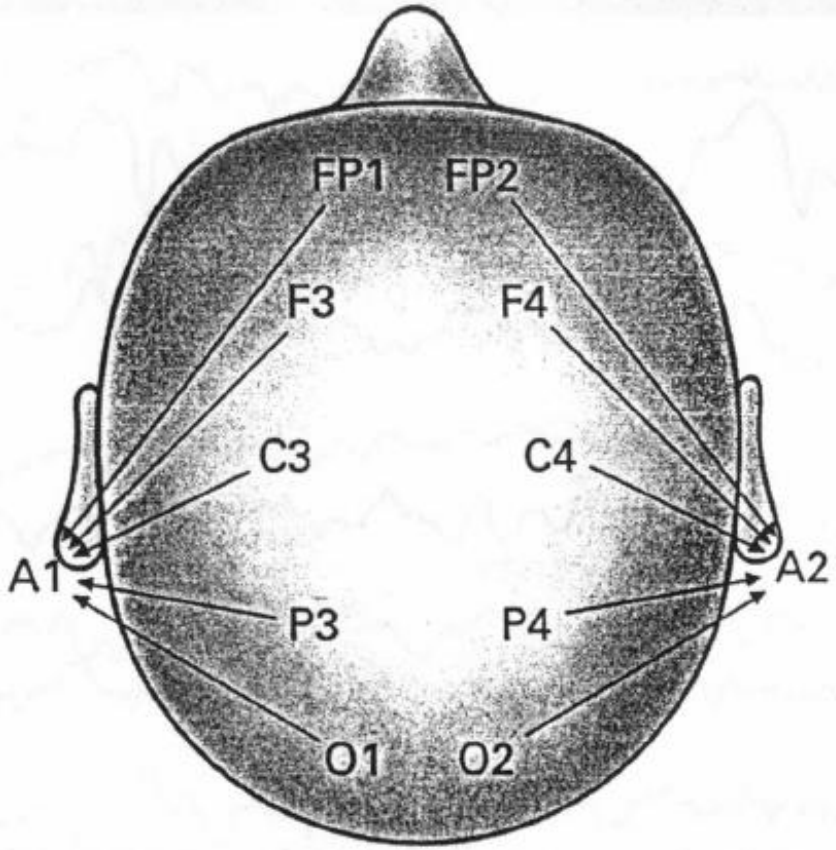


FIGURE 2b. IPSILATERAL EAR REFERENCE MONTAGE



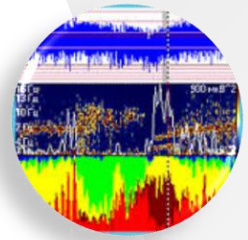
4. SYSTEMATIC APPROACH TO EEG INTERPRETATION

Types of EEG recording in practice

Routine EEG (30 minutes)

Presurgical evaluation
Prolonged scalp video-EEG monitoring
Intracranial EEG recording (IEEG)

Continuous EEG monitoring (cEEG) in ICU

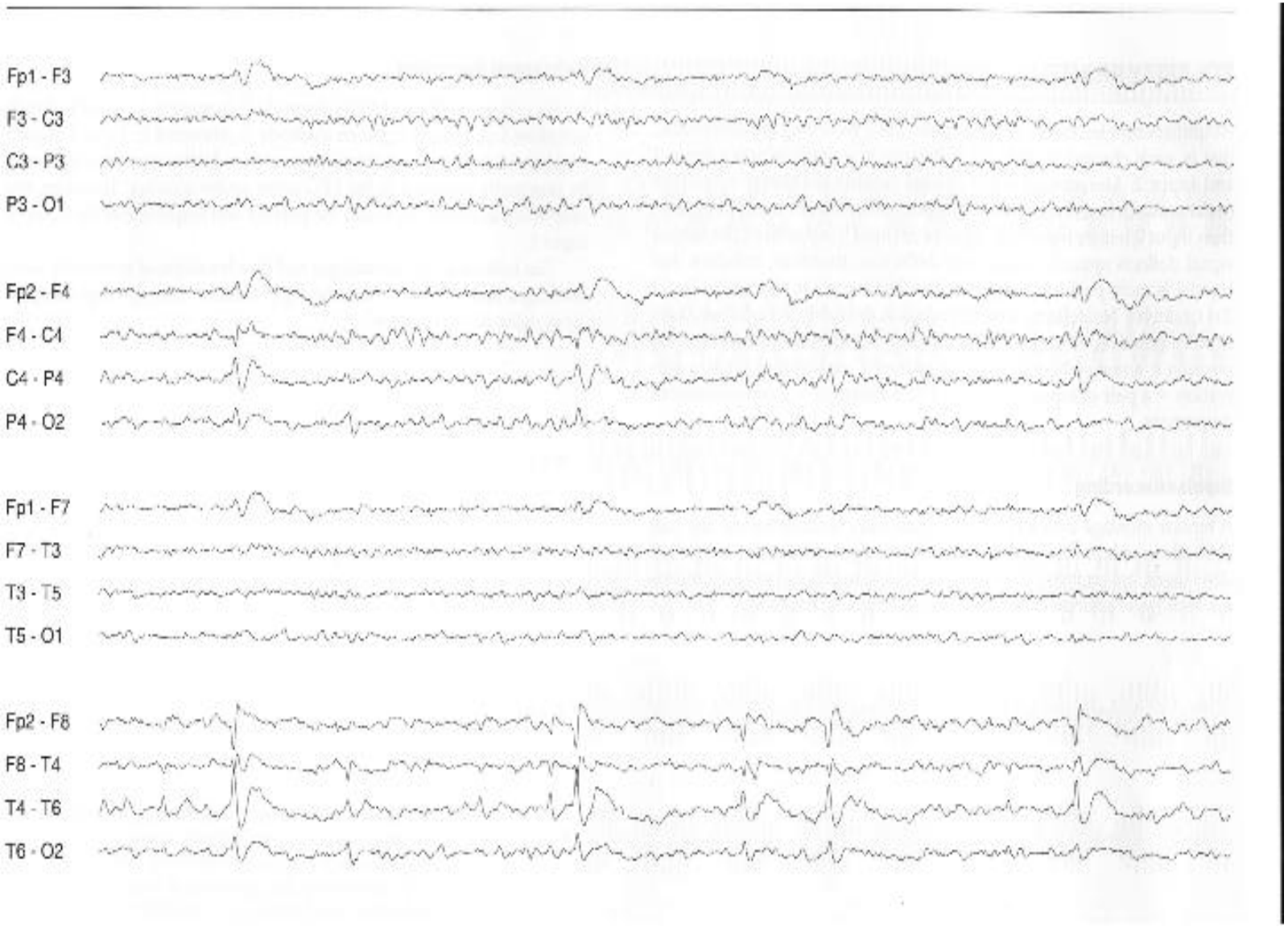


Quantitative EEG recording (QEEG)

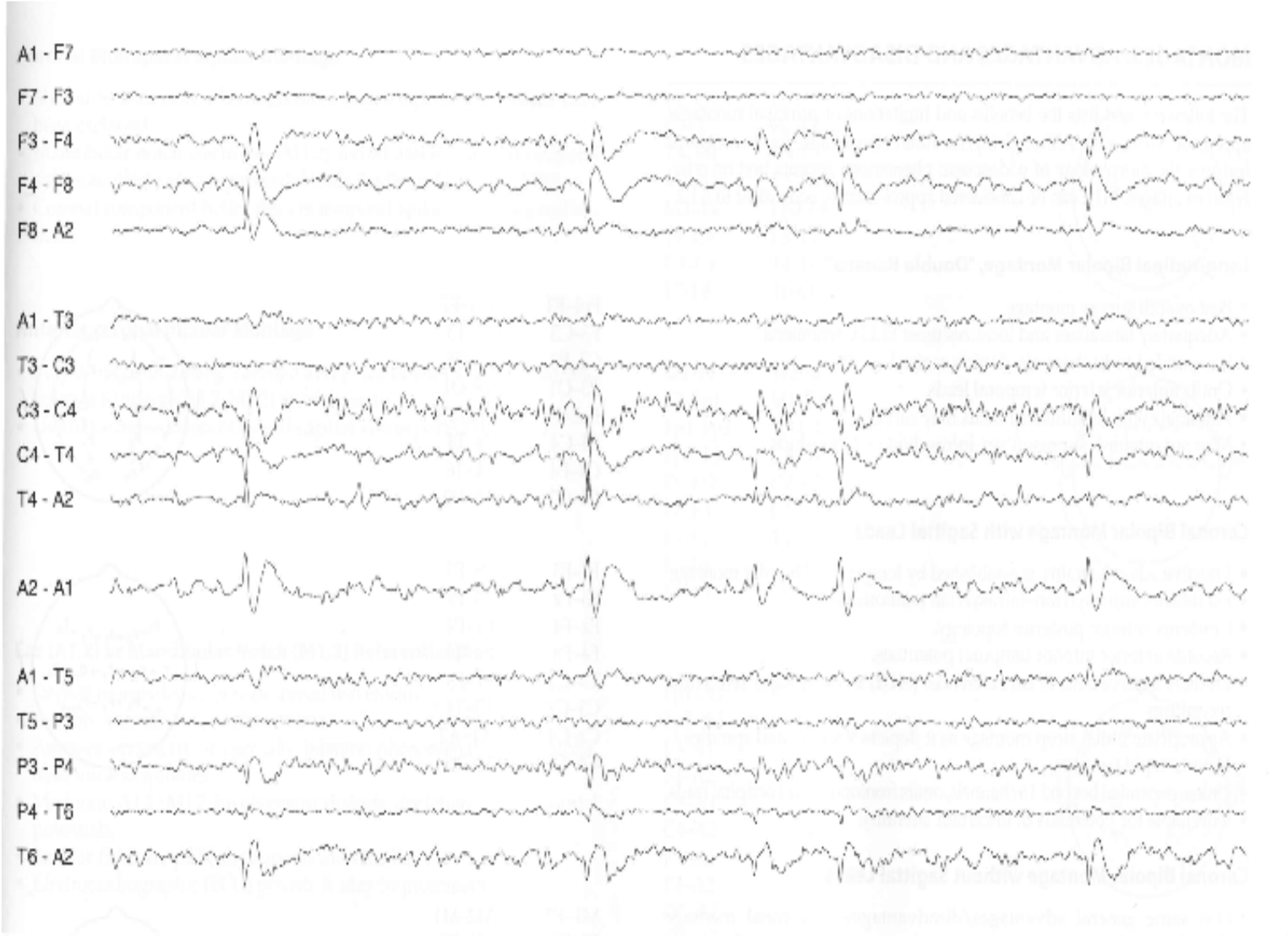
Orderly approach to start interpreting the EEGs

- **Identify montages**

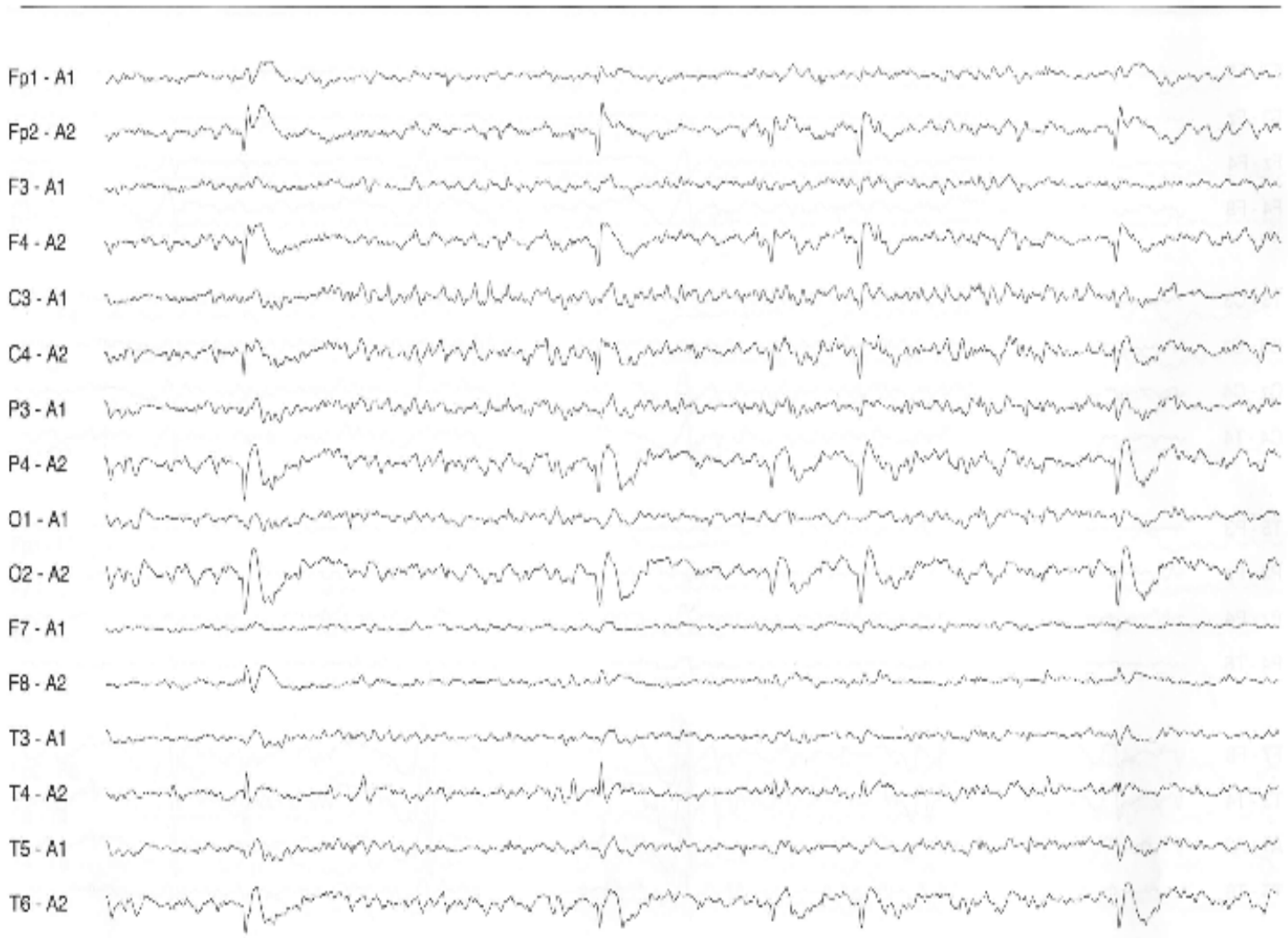
- **Define age and stage**



Antero-posterior bipolar montage



Transverse (coronal) bipolar montage



Ipsilateral ear Referential montage

Orderly approach to start interpreting the EEGs (cont.)

- Only information required before EEG analysis

➢ **Age**

➢ **State** (awake, sleep, drowsy, lethargic, stuporous, semi-coma, coma, etc.)

✓ It is a good teaching exercise and a test of analytic acumen to read a record occasionally when only one or neither of these two items is known

Essential characteristics of EEG analysis

- **Frequency**
- Voltage
- **Waveform (spike/sharp/slow)**
- Regulation
  - Frequency
  - Voltage
- Manner of occurrence (random, serial, continuous)
- **Stage of occurrence (awake, drowsy, sleep)**
- **Locus**
- Reactivity
- Interhemispheric coherence
  a. Symmetry
     - voltage
     - frequency
  b. Synchrony
     - wave
     - burst

Normal

Abnormal

- Epileptiform abnormalities
- Non-epileptiform abnormalities

Benign variants

Artifacts

- Biological (EKG, EMG, EM, tongue)
- Non-biological (electrode, movements)

Outline of thought
When you see the brain waves

GUIDELINES FOR WRITING EEG REPORTS

American Clinical Neurophysiology Society

THE GUIDELINES ARE NOT MEANT TO REPRESENT RIGID RULES BUT ONLY A GENERAL GUIDE FOR REPORTING EEGS

Three principal parts

- Introduction

- Description

- Interpretation
  - impression
  - clinical correlation

Introduction

- Medications
- Patient’s state of consciousness
- Other preparations: sleep deprivation
- Additional electrodes
- Duration of the recording, if shorter or longer than standard recording time

Description

- The description should include all the characteristics of the record, both normal and abnormal, presented in an objective way, **avoiding as much as possible, judgement about their significance**

Description (cont.)

- **Background activity (awake and sleep)**

  - dominant activity; frequency, quantity, location, amplitude, symmetry or asymmetry, rhythmic or irregular

  - reactivity

- **Abnormalities** ; spikes, slow waves
- **Activation procedures**

Interpretation

- **Impression**

  - interpreter’s subjective statement about the normality or abnormality of the record

  - grading of the abnormality; to facilitate comparison between successive records for the person who receives the report; vary from lab to lab

Interpretation (cont.)

- **Clinical correlation**

  - an attempt to explain how the EEG findings fit (or do not fit) the total clinical picture

  - more careful wording is necessary if the recipient is not versed in EEG or neurology

Examples

- Cerebral dysfunction: more than mild

  mild: ***minor irregularities in cerebral function***

- EDs: ***suggest potential epileptogenesis***

- EEG abnormality fit with the clinical information:

  is consistent with, is supportive the diagnosis

- Clinical manifestation present at the time of the recording: ***is diagnostic of***

5. NORMAL EEG PATTERNS

Frequency

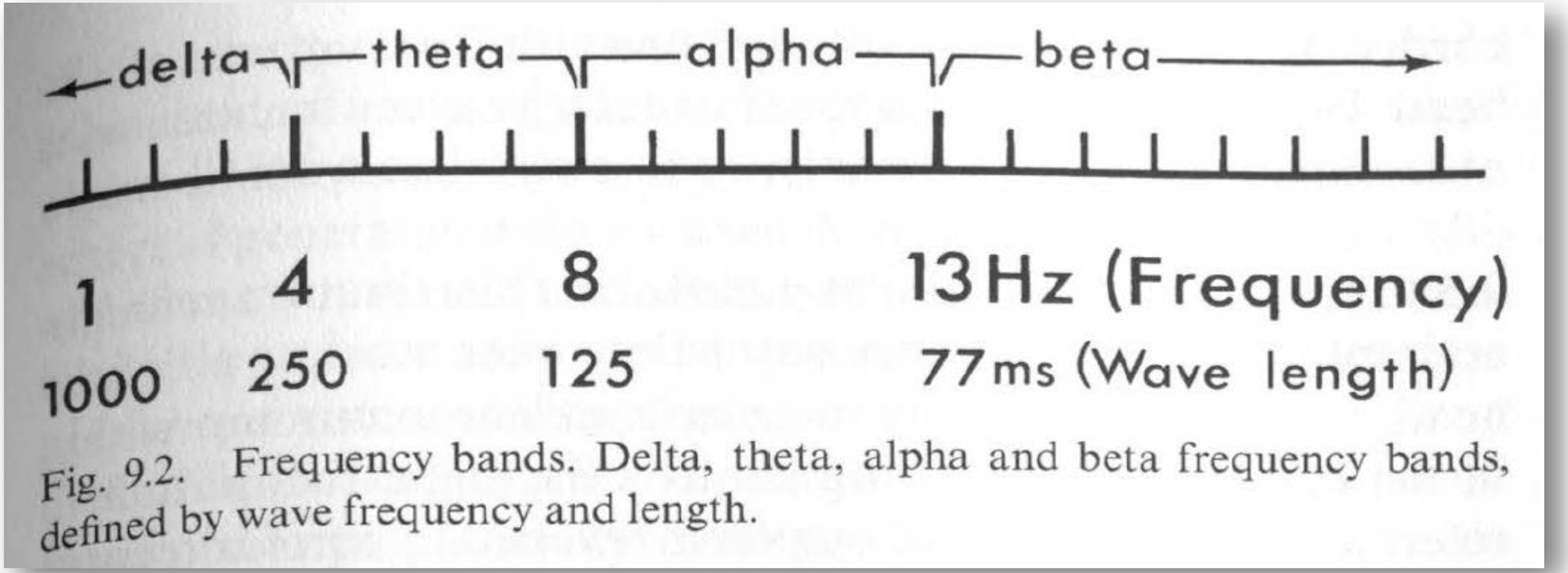


Fig. 9.2. Frequency bands. Delta, theta, alpha and beta frequency bands, defined by wave frequency and length.

Various wave forms

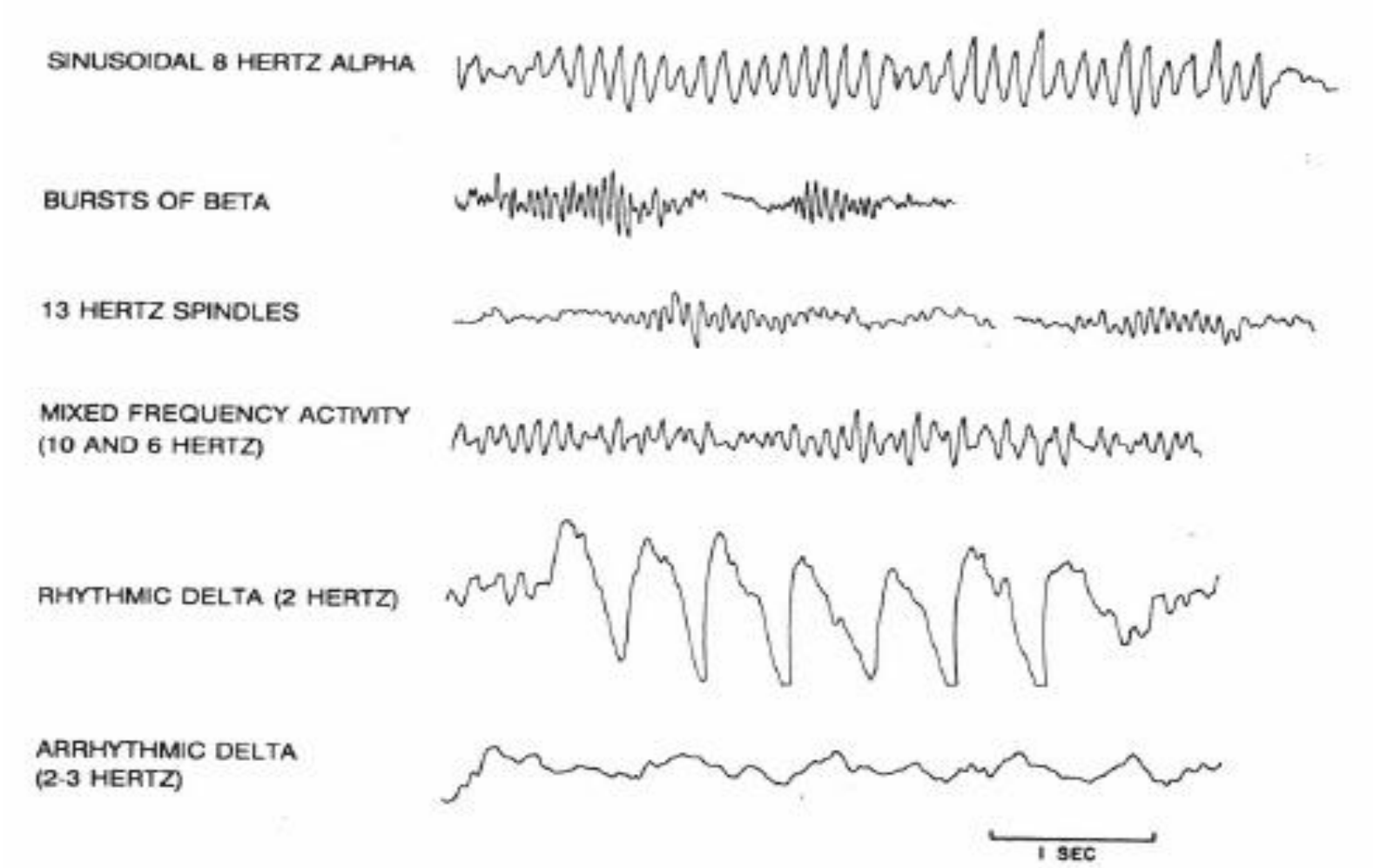
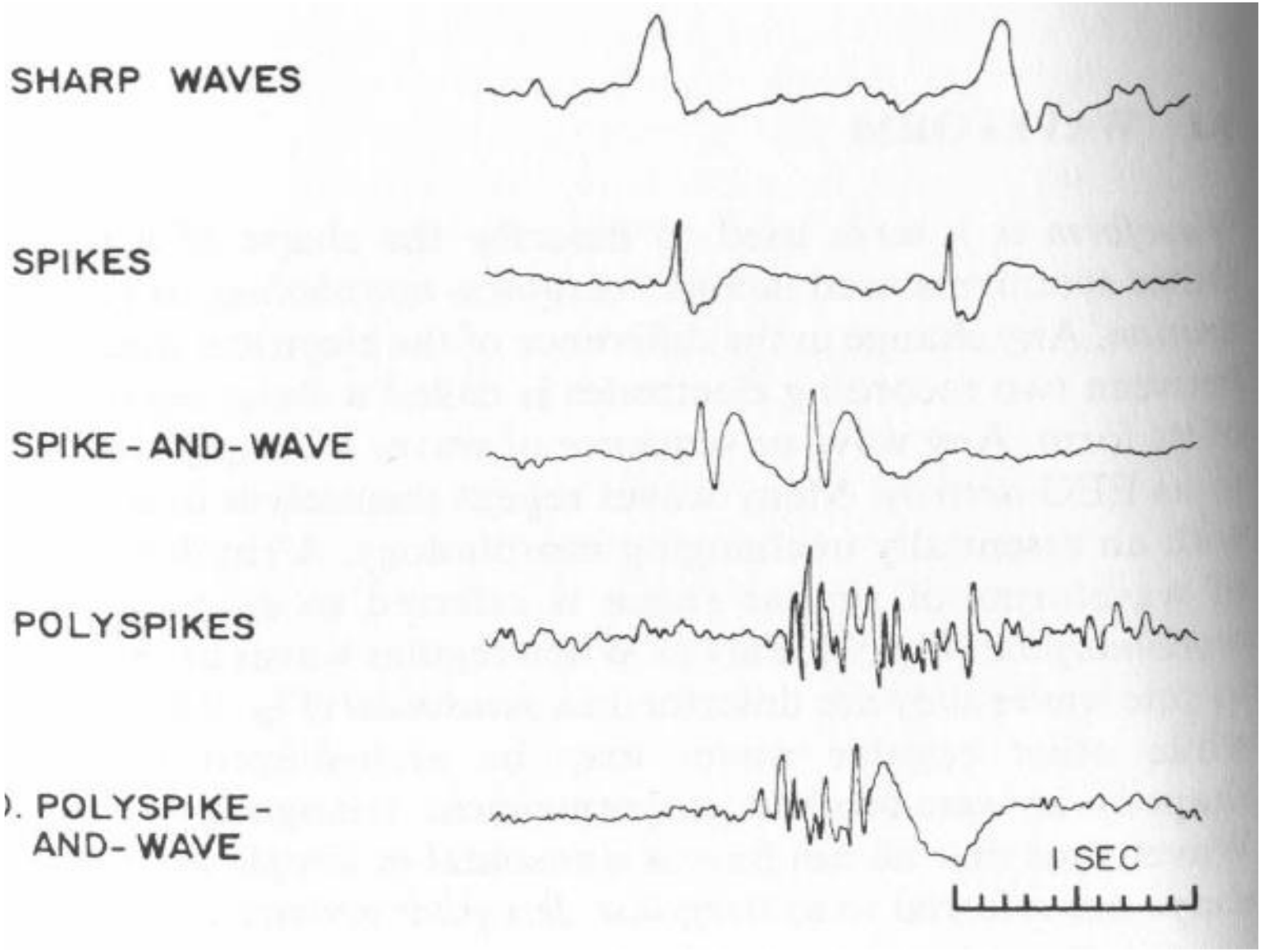


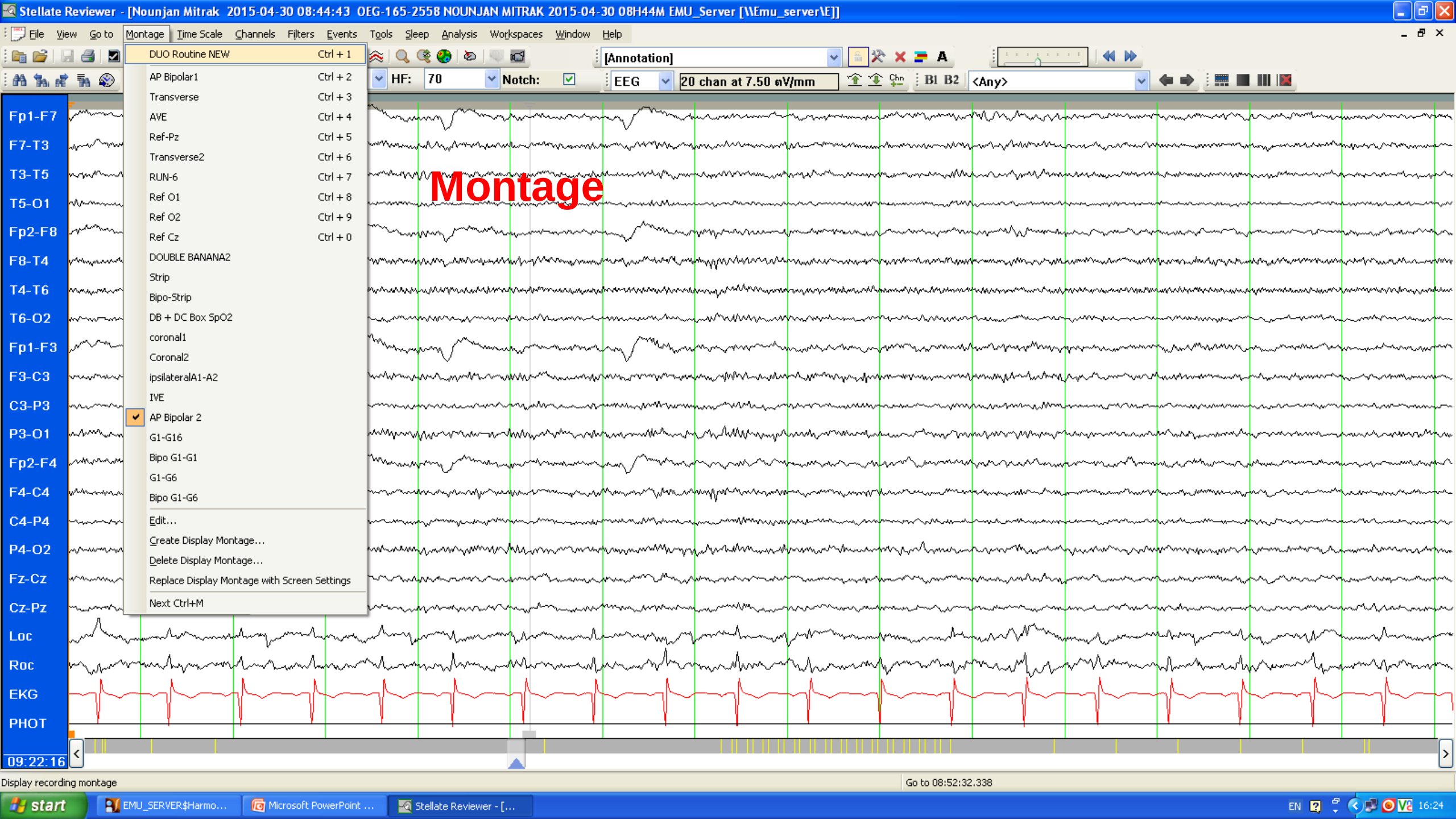
Fig. 1-2. Various waveforms. "Classical" appearance of several types of waveforms that appear in this atlas.

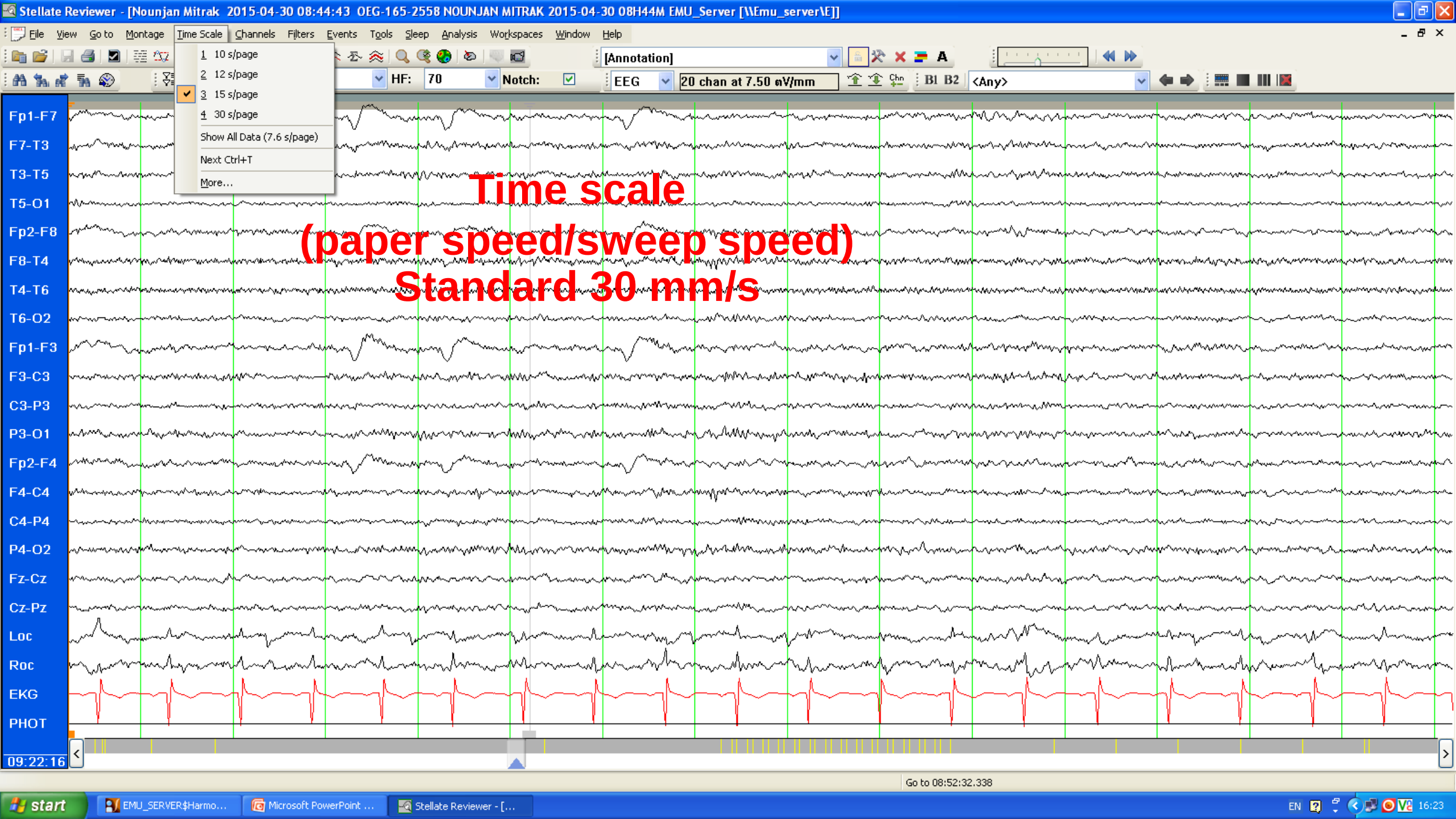
< 8 Hz = slow activity (delta; theta)

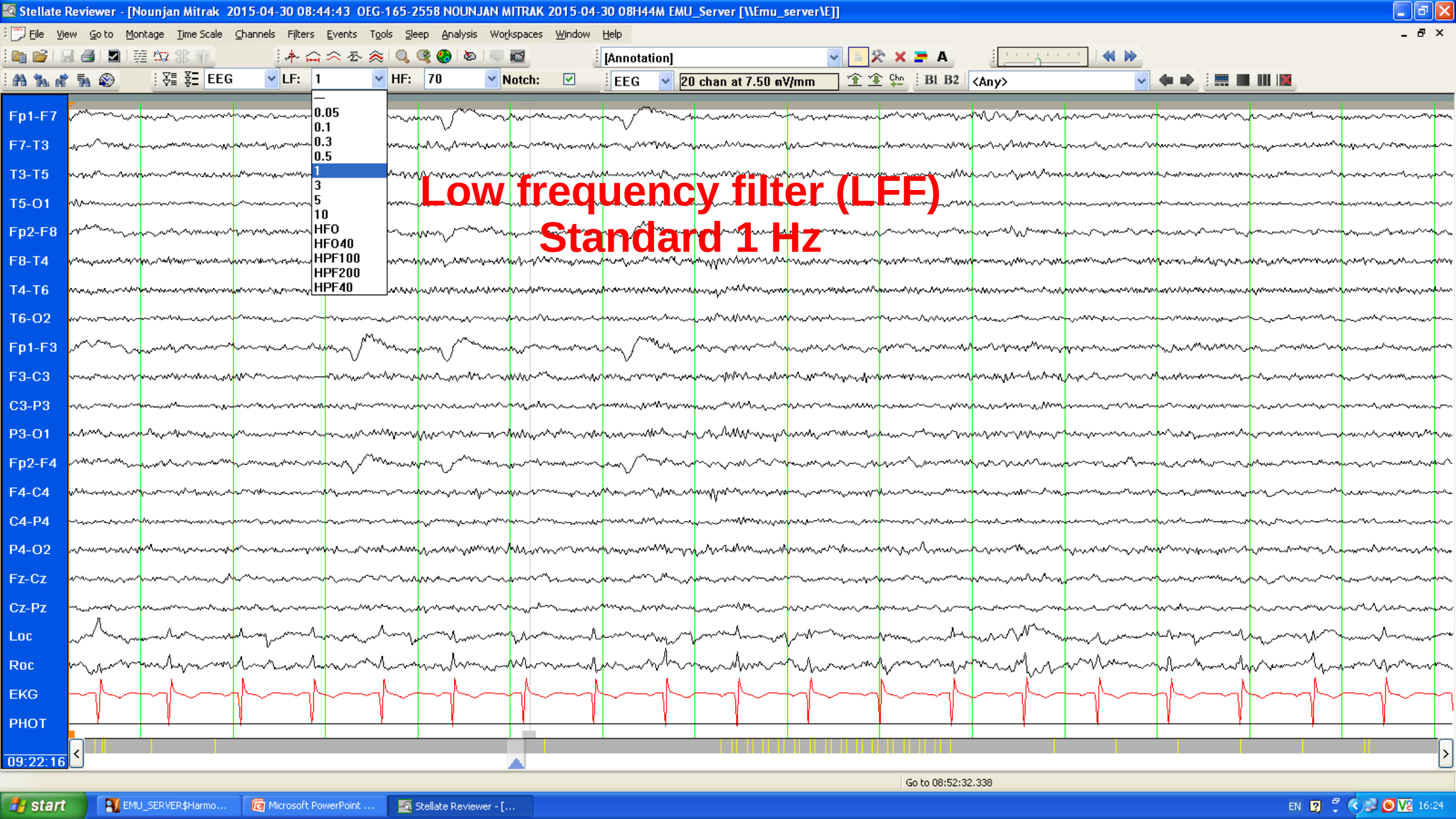
> 12 Hz = fast activity (beta, gamma)

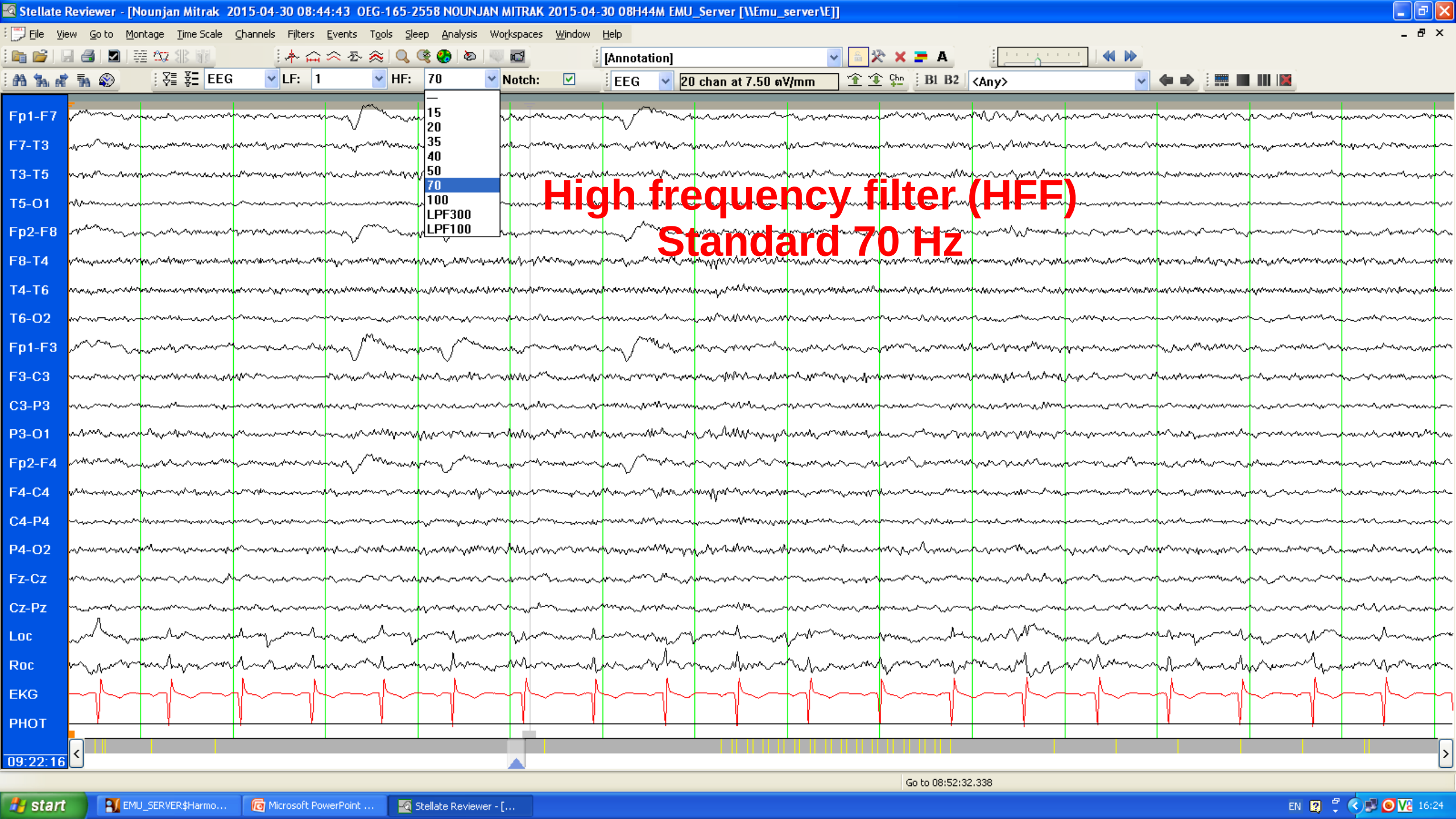


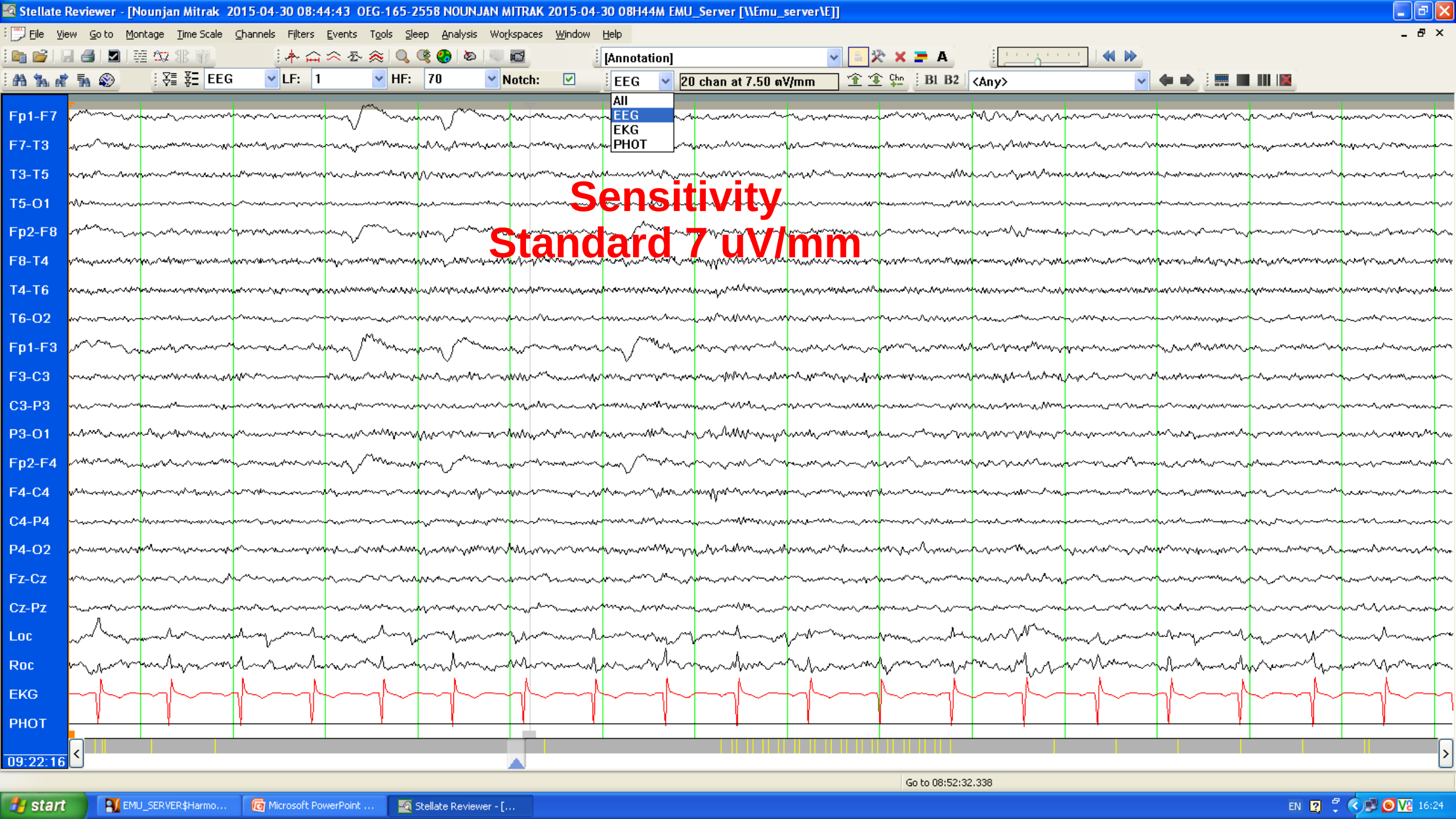
Epileptiform discharges


Stellate Reviewer - [Nounjan Mitrak 2015-04-30 08:44:43 OEG-165-2558 NOUNJAN MITRAK 2015-04-30 08H44M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
DUO Routine NEW Ctrl + 1
AP Bipolar1 Ctrl + 2
Transverse Ctrl + 3
AVE Ctrl + 4
Ref-Pz Ctrl + 5
Transverse2 Ctrl + 6
RUN-6 Ctrl + 7
Ref O1 Ctrl + 8
Ref O2 Ctrl + 9
Ref Cz Ctrl + 0
DOUBLE BANANA2
Strip
Bipo-Strip
DB + DC Box SpO2
coronal1
Coronal2
ipsilateralA1-A2
IVE
AP Bipolar 2
G1-G16
Bipo G1-G1
G1-G6
Bipo G1-G6
Edit...
Create Display Montage...
Delete Display Montage...
Replace Display Montage with Screen Settings
Next Ctrl+M
[Annotation]
HF: 70 Notch:
EEG
20 chan at 7.50 uV/mm
B1 B2
<Any>
Montage
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
09:22:16
Display recording montage
Go to 08:52:32.338
start
EMU_SERVER$Harmo...
Microsoft PowerPoint ...
Stellate Reviewer - [...
EN
16:24

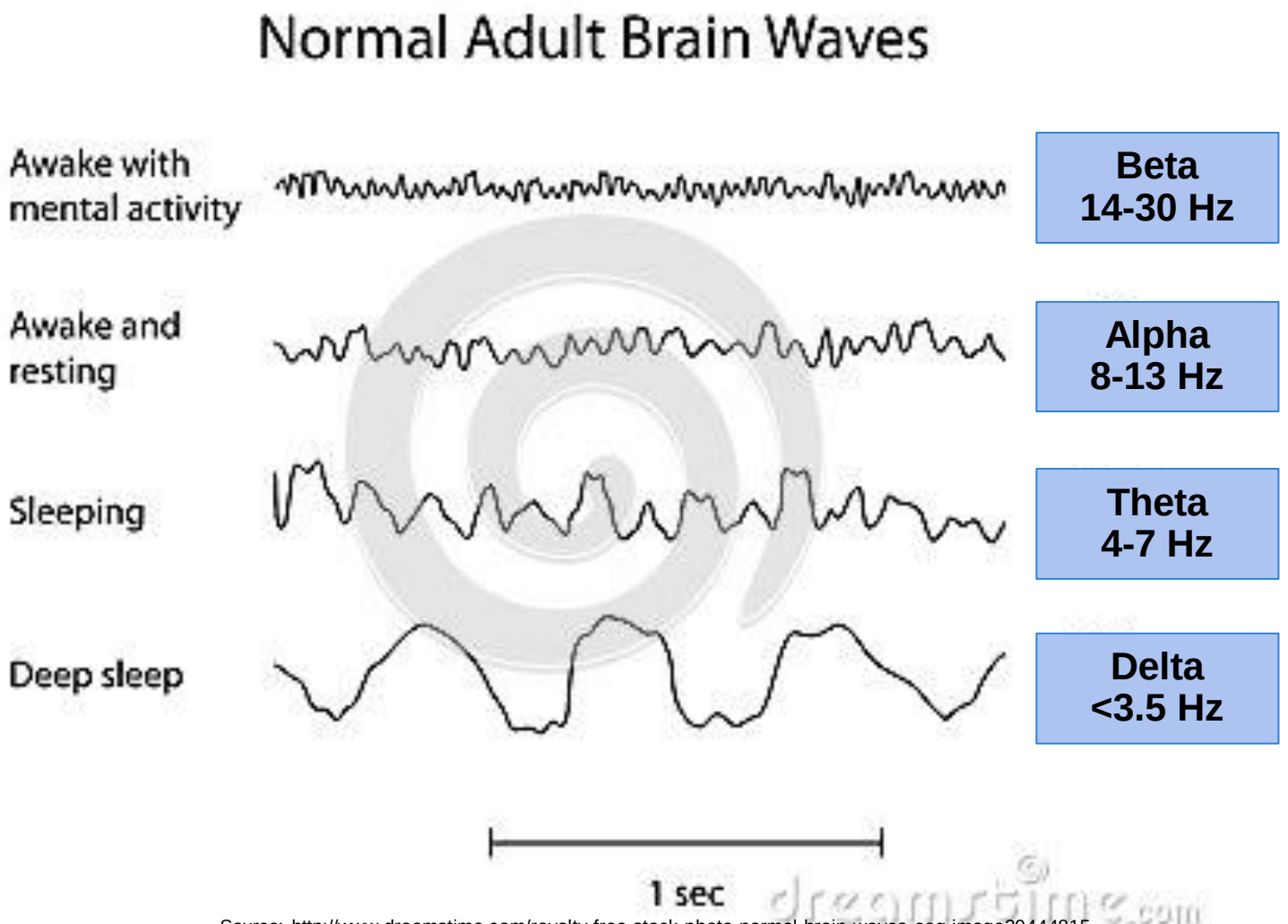

Stellate Reviewer - [Nounjan Mitrak 2015-04-30 08:44:43 OEG-165-2558 NOUNJAN MITRAK 2015-04-30 08H44M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
1 10 s/page
2 12 s/page
3 15 s/page
4 30 s/page
Show All Data (7.6 s/page)
Next Ctrl+T
More...
HF: 70 Notch:
[Annotation]
EEG
20 chan at 7.50 uV/mm
B1 B2
<Any>
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
09:22:16
Time scale
(paper speed/sweep speed)
Standard 30 mm/s
Go to 08:52:32.338
start
EMU_SERVER$Harmo...
Microsoft PowerPoint ...
Stellate Reviewer - [...
EN
16:23


Stellate Reviewer - [Nounjan Mitrak 2015-04-30 08:44:43 OEG-165-2558 NOUNJAN MITRAK 2015-04-30 08H44M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Annotation]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2 <Any>
—
0.05
0.1
0.3
0.5
1
3
5
10
HFO
HFO40
HPF100
HPF200
HPF40
Low frequency filter (LFF)
Standard 1 Hz
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
09:22:16
Go to 08:52:32.338
start
EMU_SERVER$Harmo...
Microsoft PowerPoint ...
Stellate Reviewer - [...
EN
16:24

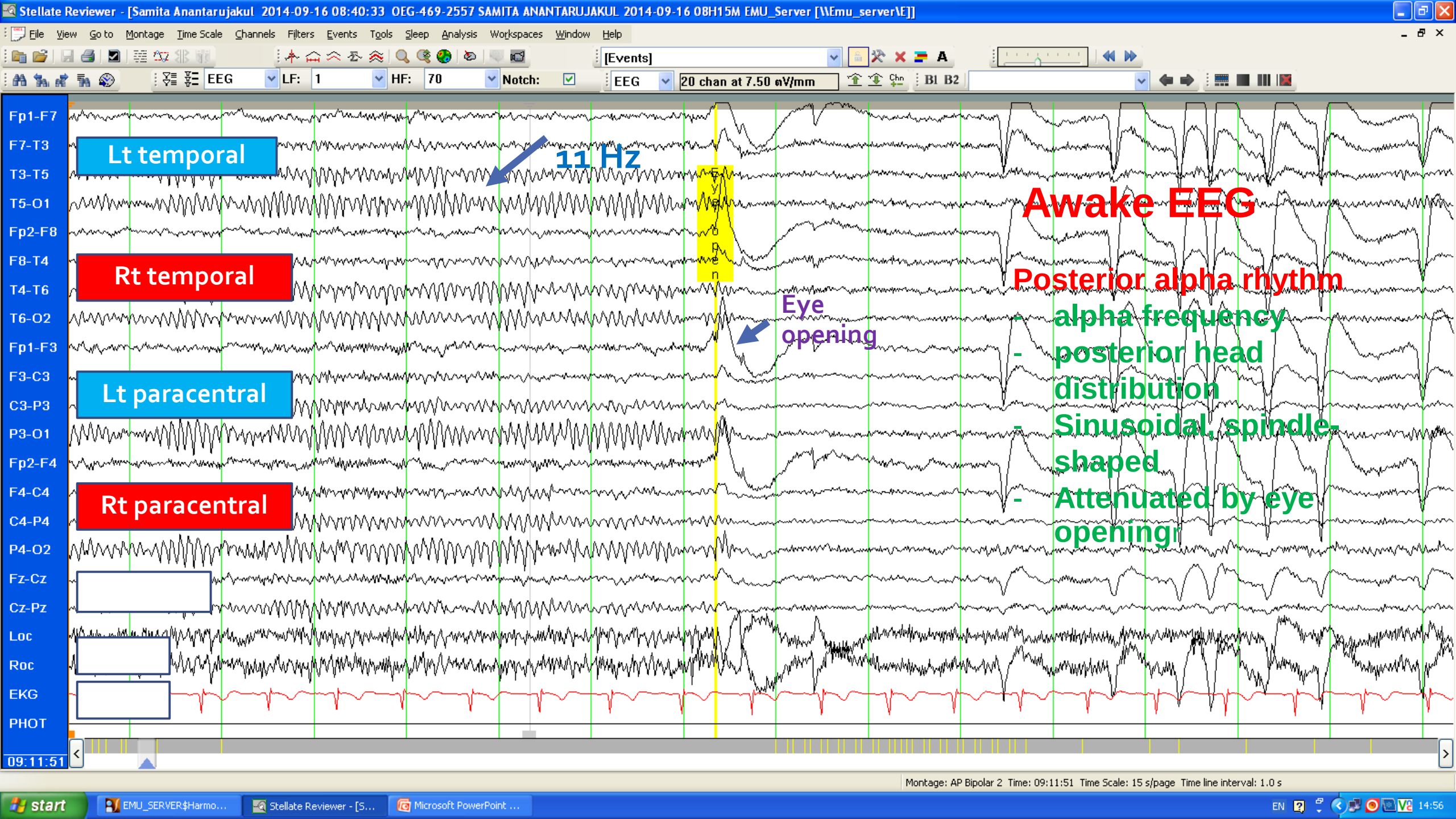

Stellate Reviewer - [Nounjan Mitrak 2015-04-30 08:44:43 OEG-165-2558 NOUNJAN MITRAK 2015-04-30 08H44M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Annotation]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2 <Any>
—
15
20
35
40
50
70
100
LPF300
LPF100
High frequency filter (HFF)
Standard 70 Hz
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
09:22:16
Go to 08:52:32.338
start
EMU_SERVER$Harmo...
Microsoft PowerPoint ...
Stellate Reviewer - [...
EN
16:24

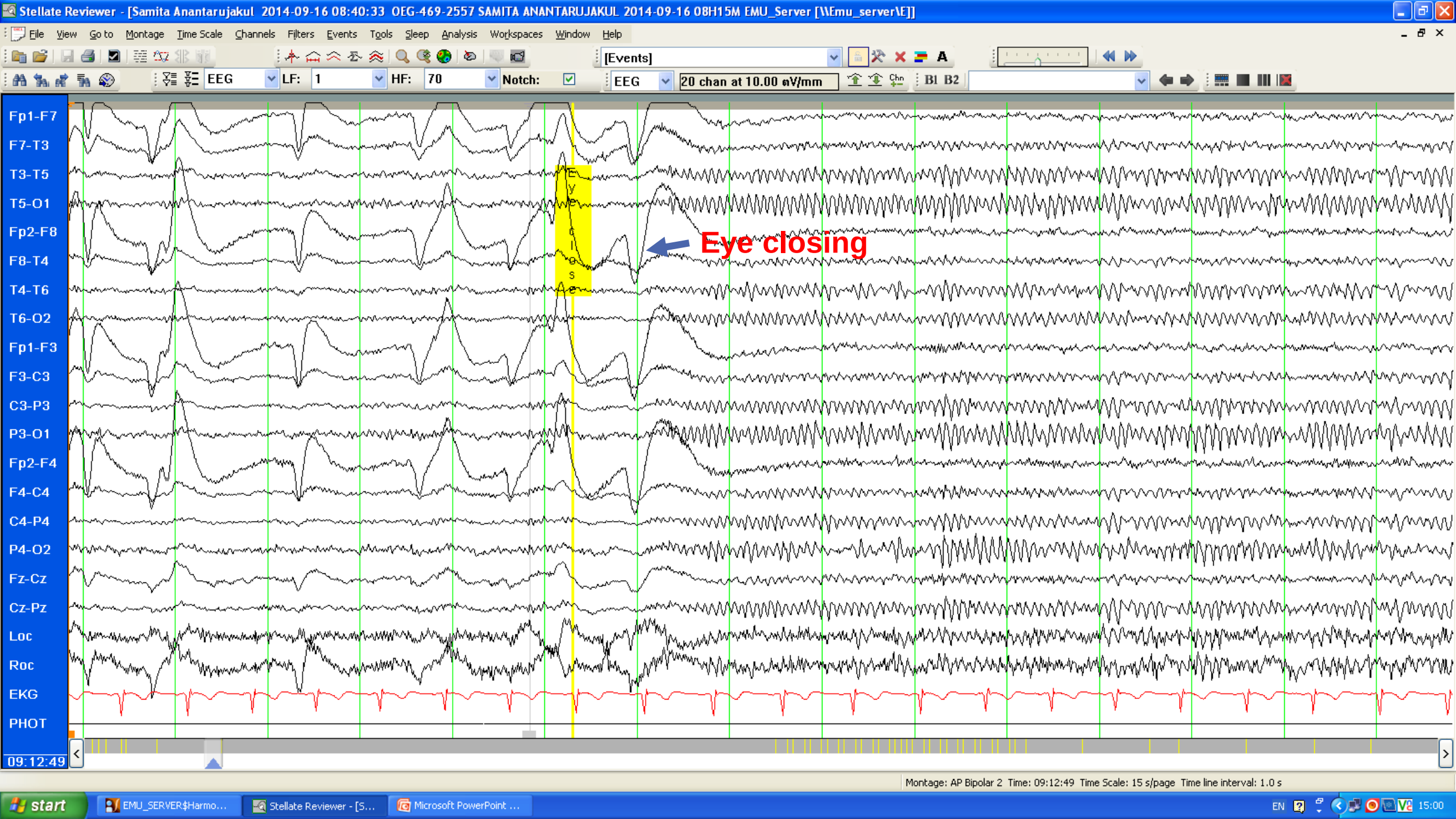

Stellate Reviewer - [Nounjan Mitrak 2015-04-30 08:44:43 OEG-165-2558 NOUNJAN MITRAK 2015-04-30 08H44M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Annotation]
EEG LF: 1 HF: 70 Notch:
EEG
20 chan at 7.50 uV/mm
All
EEG
EKG
PHOT
B1 B2
<Any>
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
Sensitivity
Standard 7 uV/mm
09:22:16
Go to 08:52:32.338
start
EMU_SERVER$Harmo...
Microsoft PowerPoint ...
Stellate Reviewer - [...
EN
16:24

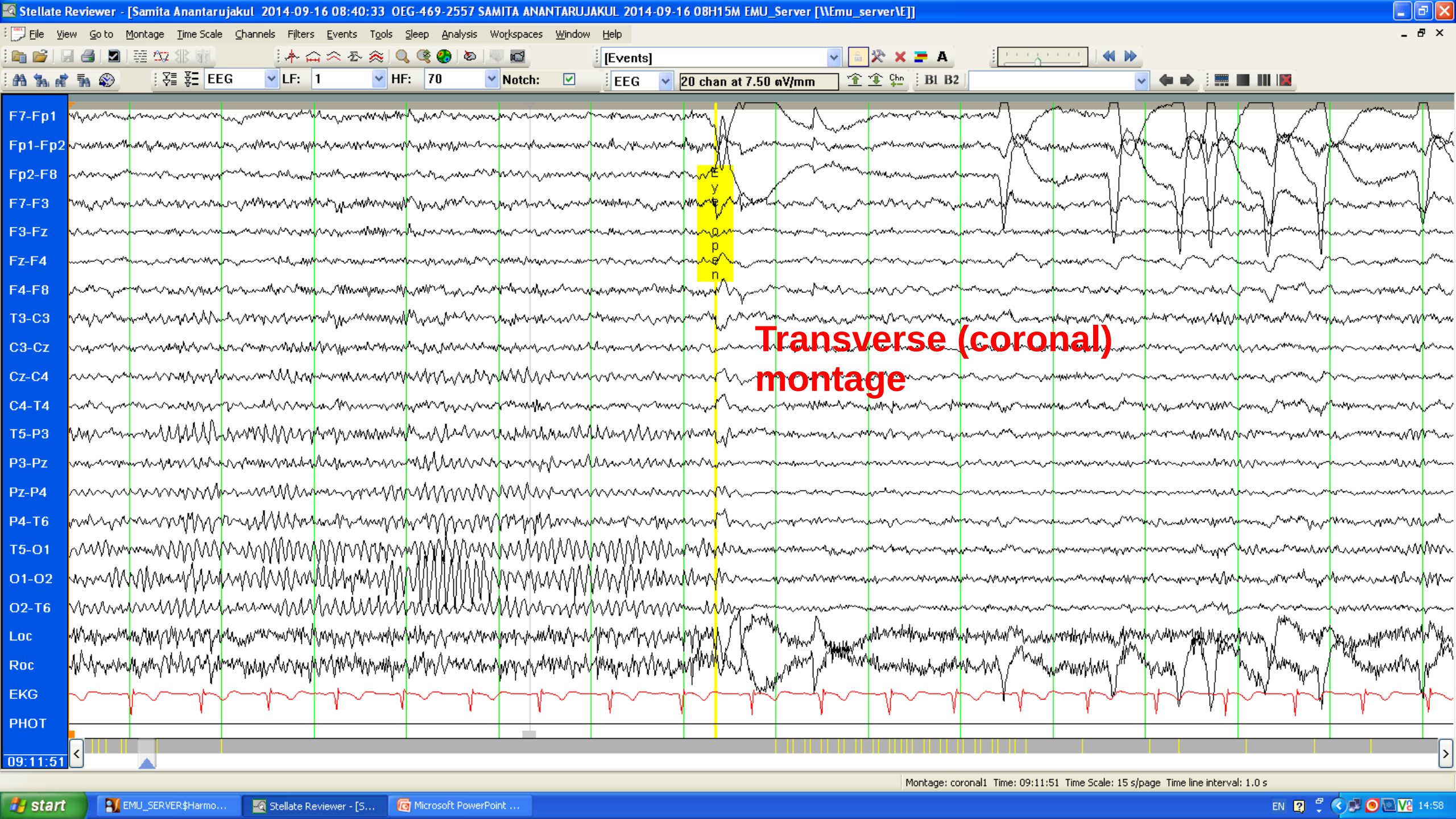
Normal EEG wave

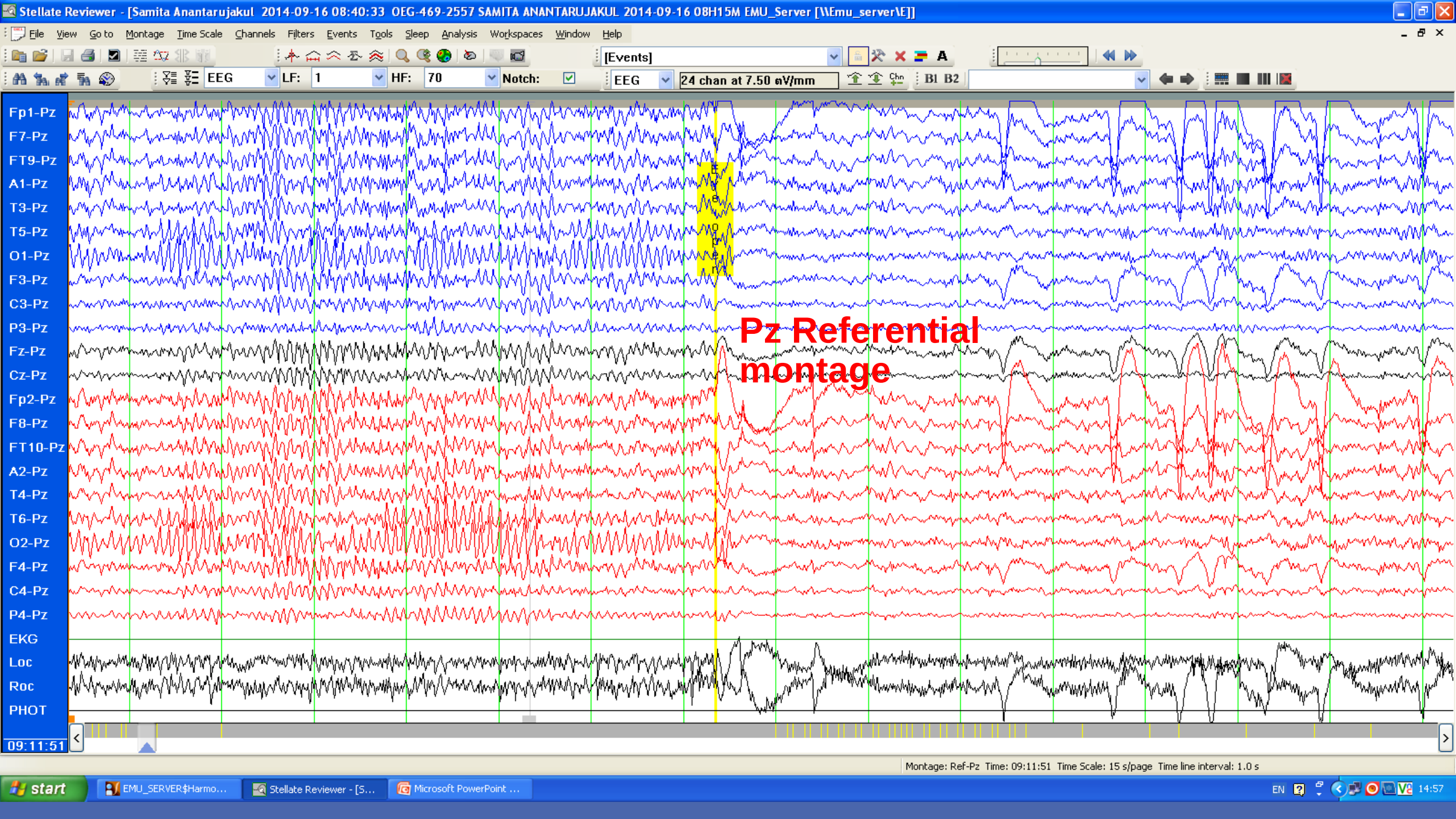


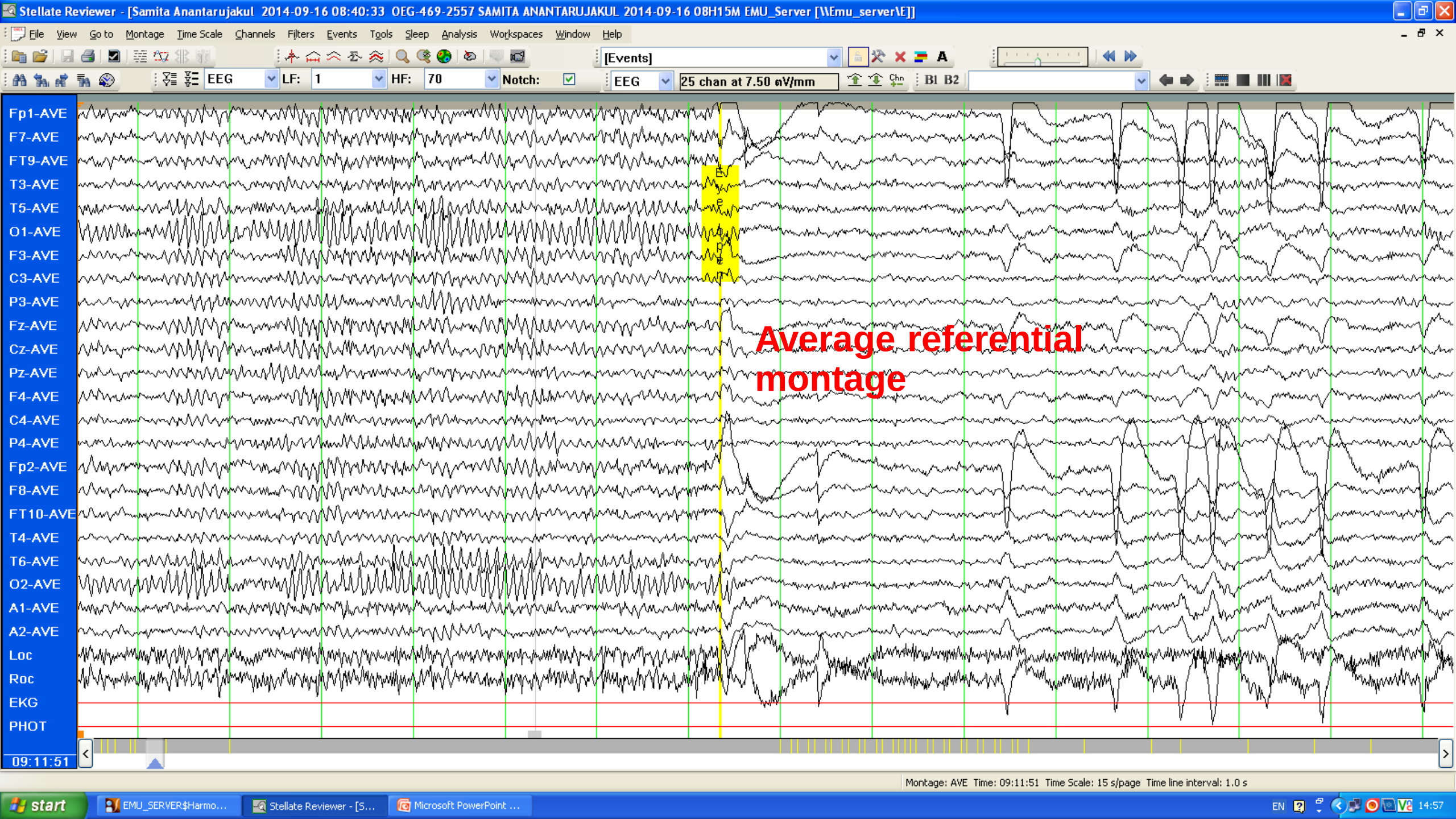
Source: http://www.dreamstime.com/royalty-free-stock-photo-normal-brain-waves-eeg-image29444815

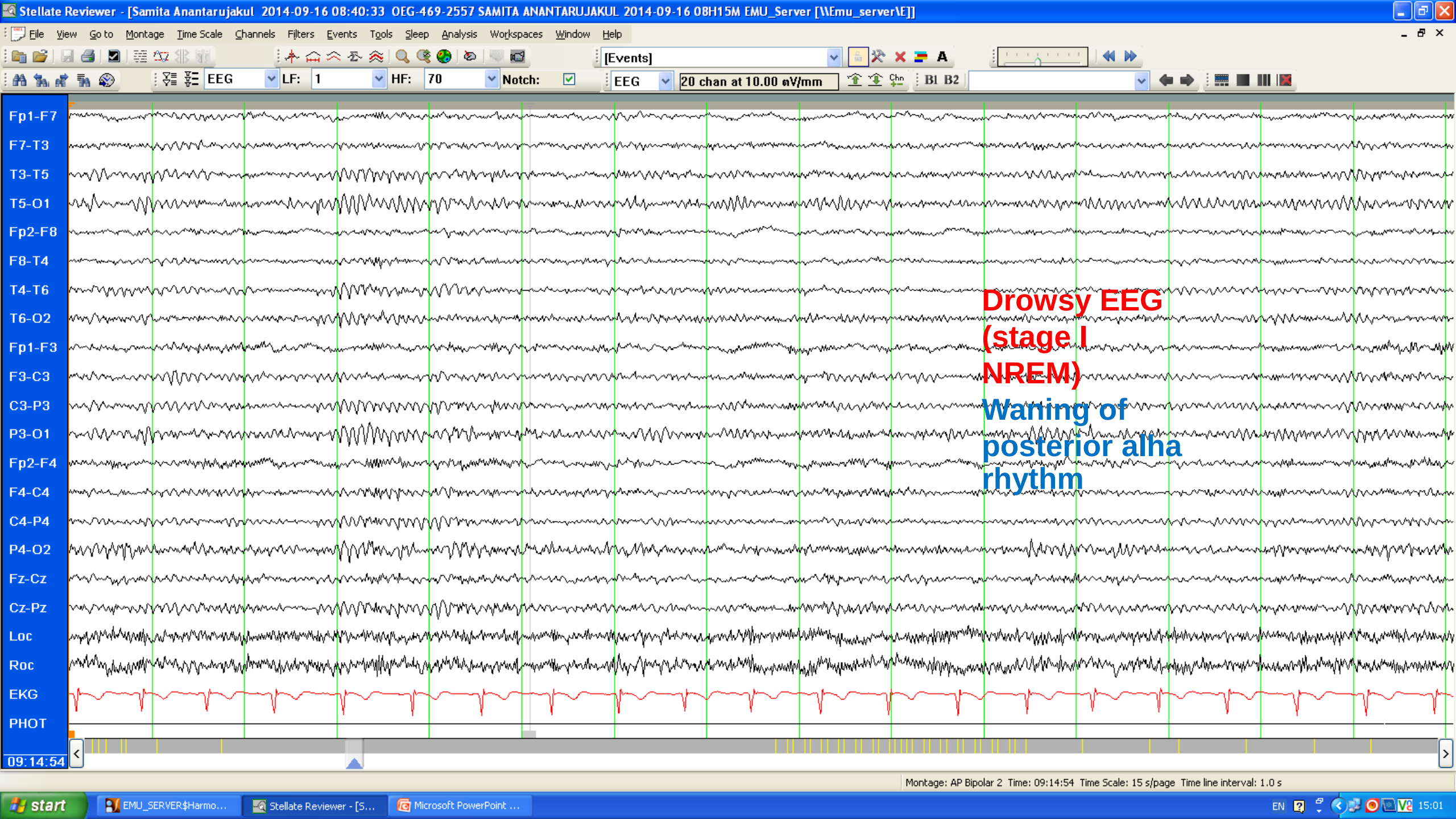

Stellate Reviewer - [Samita Anantarujakul 2014-09-16 08:40:33 OEG-469-2557 SAMITA ANANTARUJAKUL 2014-09-16 08H15M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
Lt temporal
Rt temporal
Lt paracentral
Rt paracentral
11 Hz
Eye opening
Awake EEG
Posterior alpha rhythm
- alpha frequency
- posterior head distribution
- Sinusoidal, spindle-shaped
- Attenuated by eye opening
09:11:51
Montage: AP Bipolar 2 Time: 09:11:51 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Stellate Reviewer - [S...
Microsoft PowerPoint ...
EN
14:56

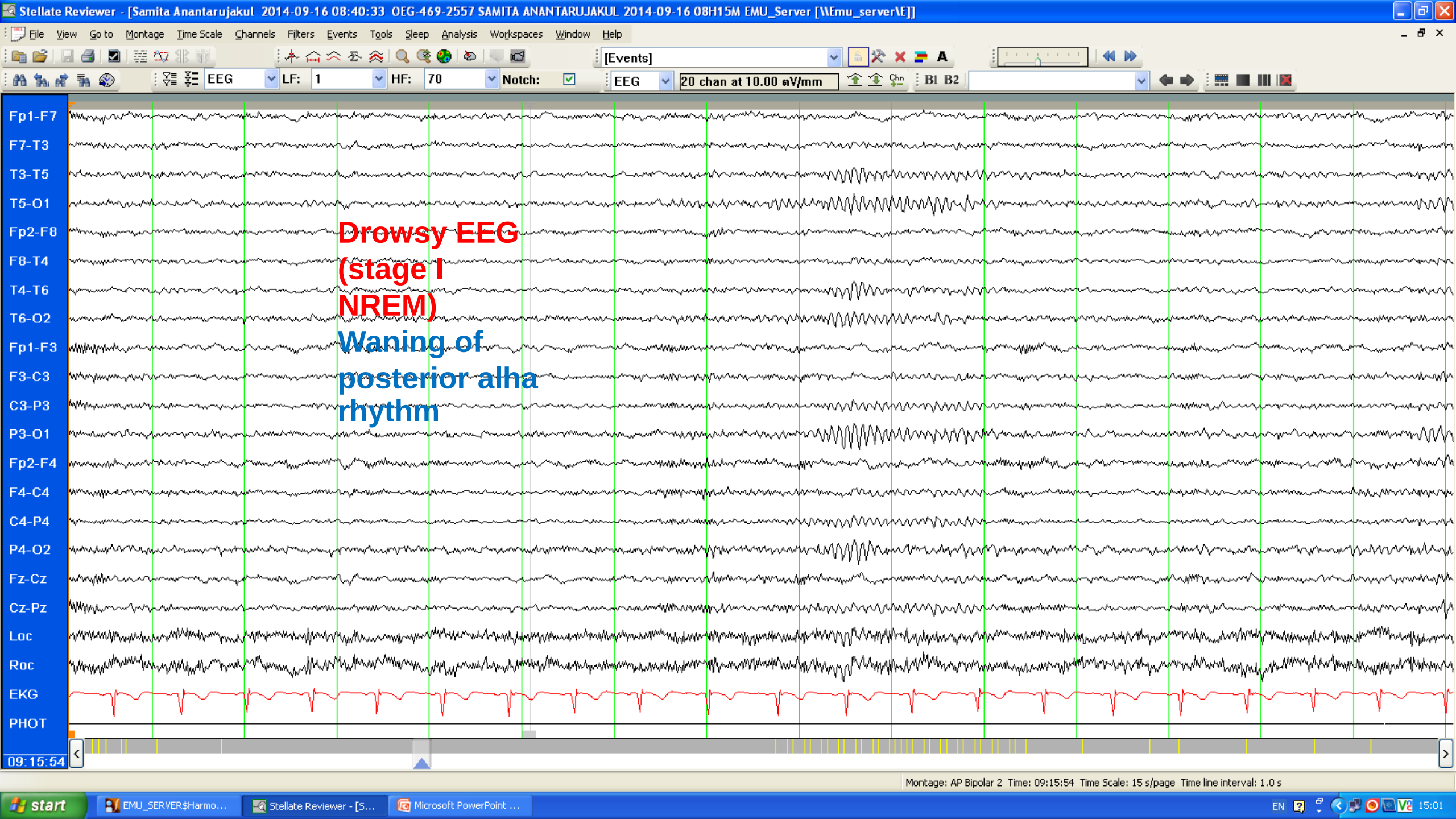

Stellate Reviewer - [Samita Anantarujakul 2014-09-16 08:40:33 OEG-469-2557 SAMITA ANANTARUJAKUL 2014-09-16 08H15M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 10.00 uV/mm
B1 B2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
Eye closing
09:12:49
Montage: AP Bipolar 2 Time: 09:12:49 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Stellate Reviewer - [S...
Microsoft PowerPoint ...
EN
15:00

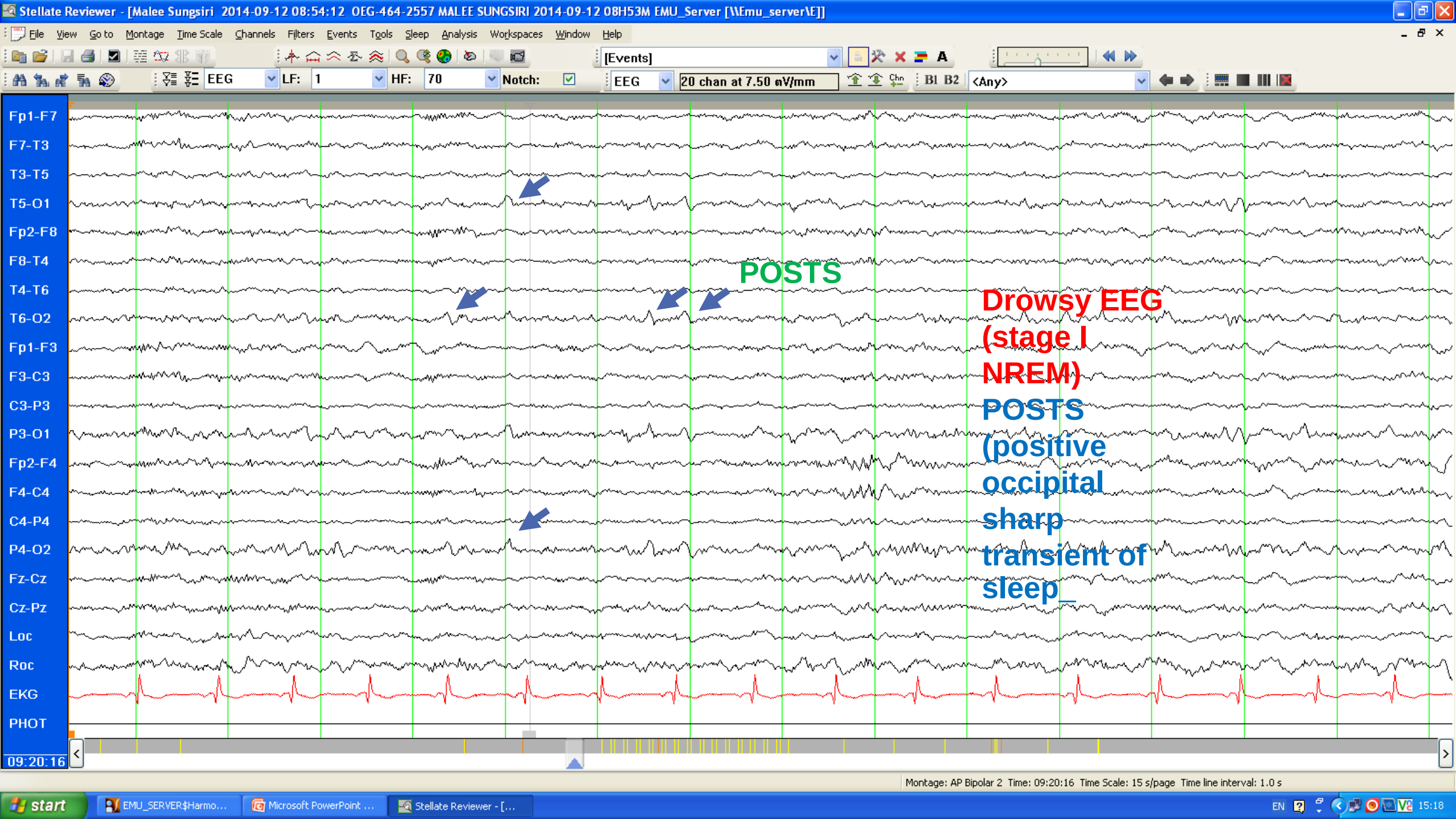

Stellate Reviewer - [Samita Anantarujakul 2014-09-16 08:40:33 OEG-469-2557 SAMITA ANANTARUJAKUL 2014-09-16 08H15M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2
F7-Fp1
Fp1-Fp2
Fp2-F8
F7-F3
F3-Fz
Fz-F4
F4-F8
T3-C3
C3-Cz
Cz-C4
C4-T4
T5-P3
P3-Pz
Pz-P4
P4-T6
T5-O1
O1-O2
O2-T6
Loc
Roc
EKG
PHOT
Eyes open
Transverse (coronal) montage
09:11:51
Montage: coronal1 Time: 09:11:51 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Stellate Reviewer - [S...
Microsoft PowerPoint ...
EN
14:58

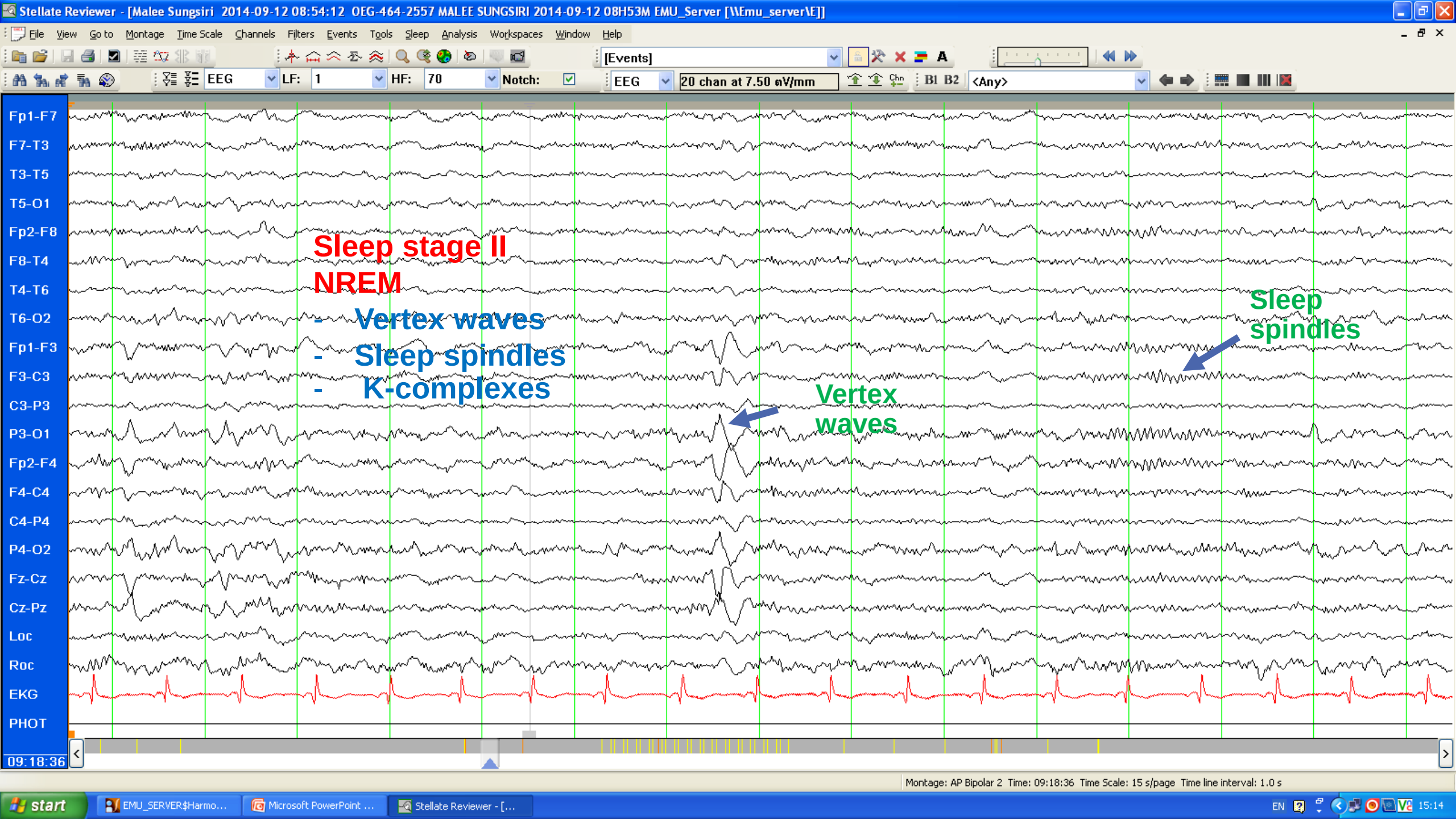

Stellate Reviewer - [Samita Anantarujakul 2014-09-16 08:40:33 OEG-469-2557 SAMITA ANANTARUJAKUL 2014-09-16 08H15M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 24 chan at 7.50 uV/mm
B1 B2
Fp1-Pz
F7-Pz
FT9-Pz
A1-Pz
T3-Pz
T5-Pz
O1-Pz
F3-Pz
C3-Pz
P3-Pz
Fz-Pz
Cz-Pz
Fp2-Pz
F8-Pz
FT10-Pz
A2-Pz
T4-Pz
T6-Pz
O2-Pz
F4-Pz
C4-Pz
P4-Pz
EKG
Loc
Roc
PHOT
Pz Referential montage
09:11:51
Montage: Ref-Pz Time: 09:11:51 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Stellate Reviewer - [S...
Microsoft PowerPoint ...
EN
14:57

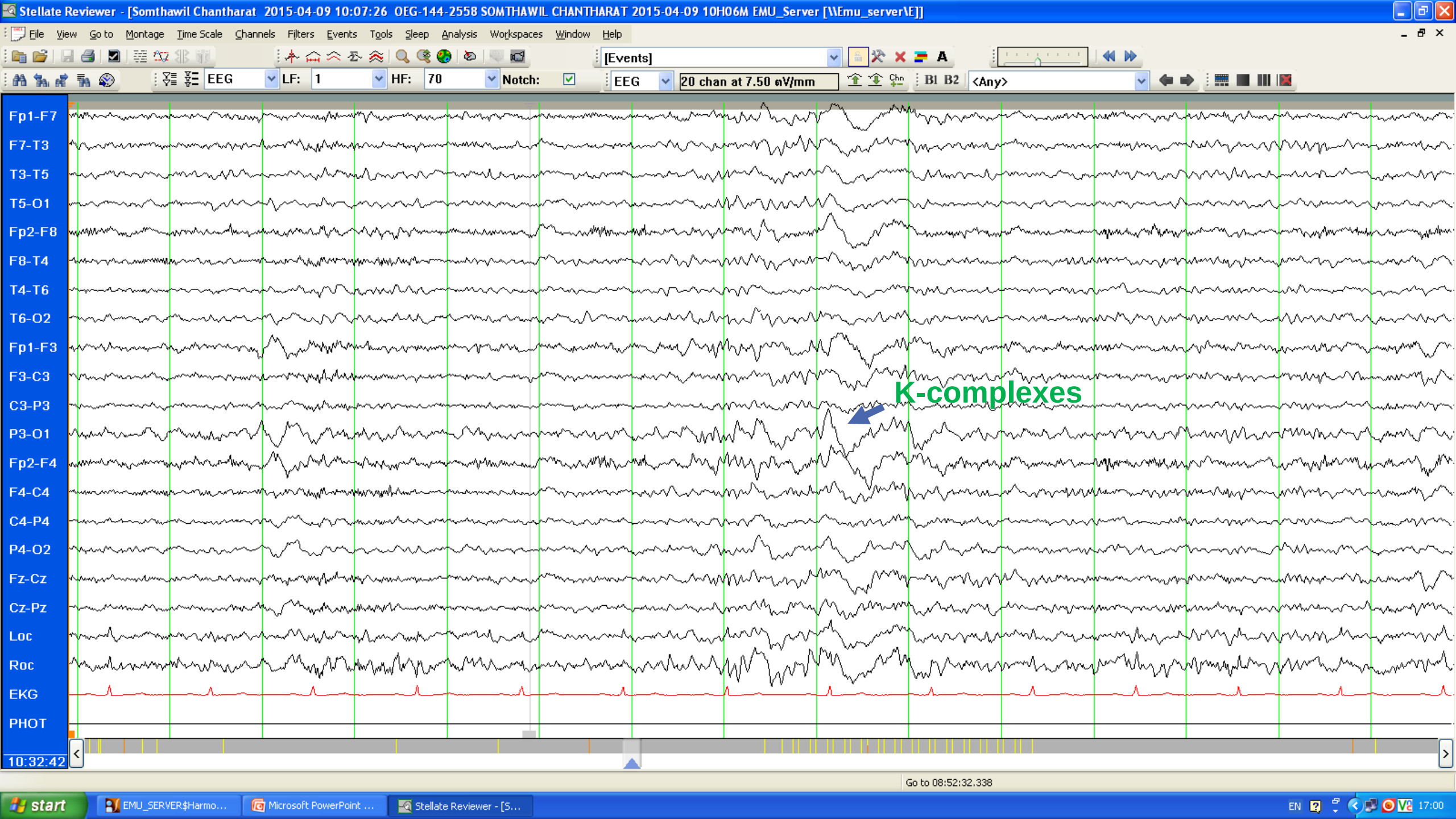

Stellate Reviewer - [Samita Anantarujakul 2014-09-16 08:40:33 OEG-469-2557 SAMITA ANANTARUJAKUL 2014-09-16 08H15M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 25 chan at 7.50 uV/mm
B1 B2
Fp1-AVE
F7-AVE
FT9-AVE
T3-AVE
T5-AVE
O1-AVE
F3-AVE
C3-AVE
P3-AVE
Fz-AVE
Cz-AVE
Pz-AVE
F4-AVE
C4-AVE
P4-AVE
Fp2-AVE
F8-AVE
FT10-AVE
T4-AVE
T6-AVE
O2-AVE
A1-AVE
A2-AVE
Loc
Roc
EKG
PHOT
09:11:51
Average referential montage
Montage: AVE Time: 09:11:51 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Stellate Reviewer - [S...
Microsoft PowerPoint ...
EN
14:57

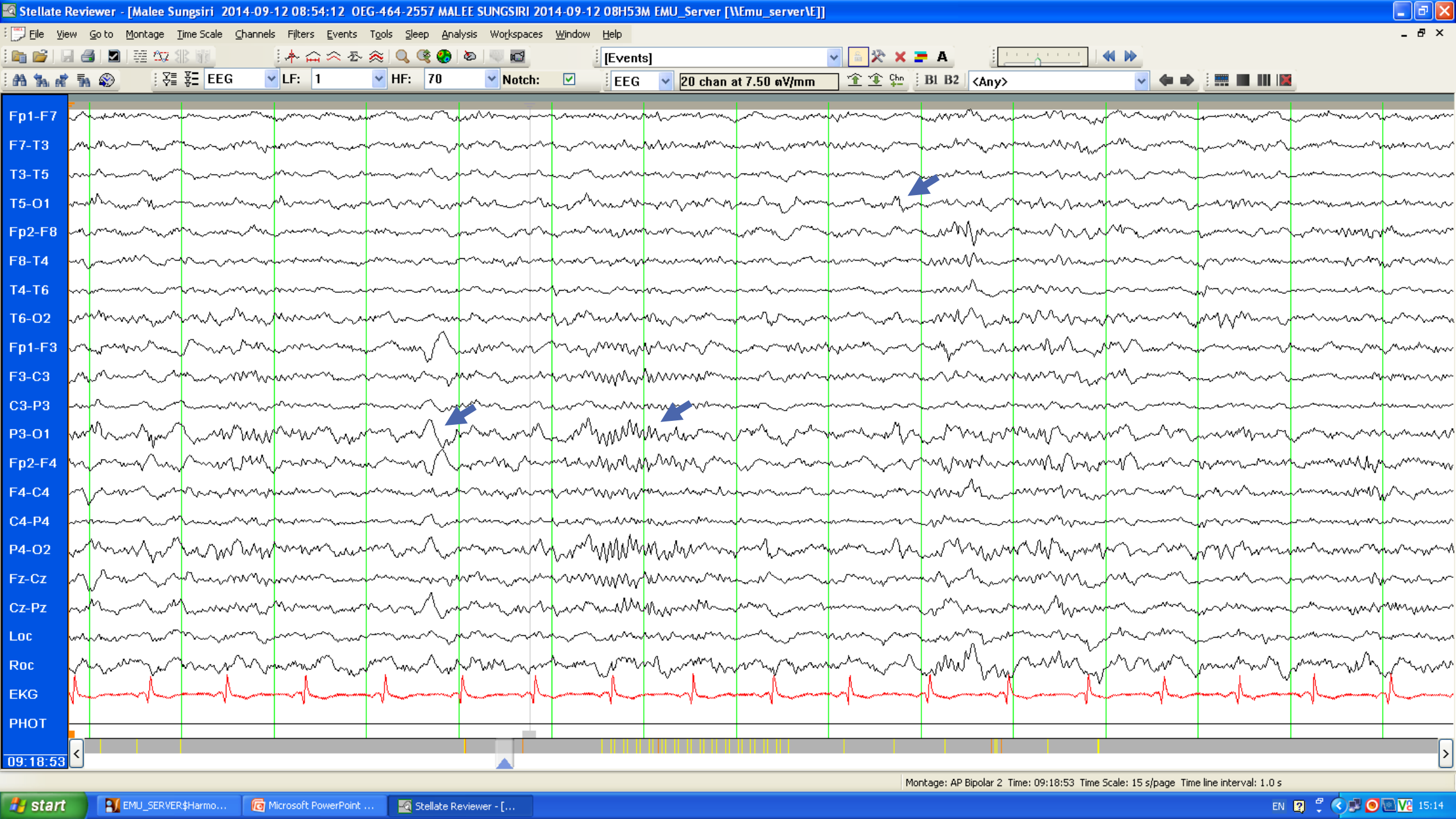

Stellate Reviewer - [Samita Anantarujakul 2014-09-16 08:40:33 OEG-469-2557 SAMITA ANANTARUJAKUL 2014-09-16 08H15M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 10.00 uV/mm
B1 B2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
09:14:54
Drowsy EEG (stage I NREM)
Waning of posterior alha rhythm
Montage: AP Bipolar 2 Time: 09:14:54 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Stellate Reviewer - [S...
Microsoft PowerPoint ...
EN
15:01

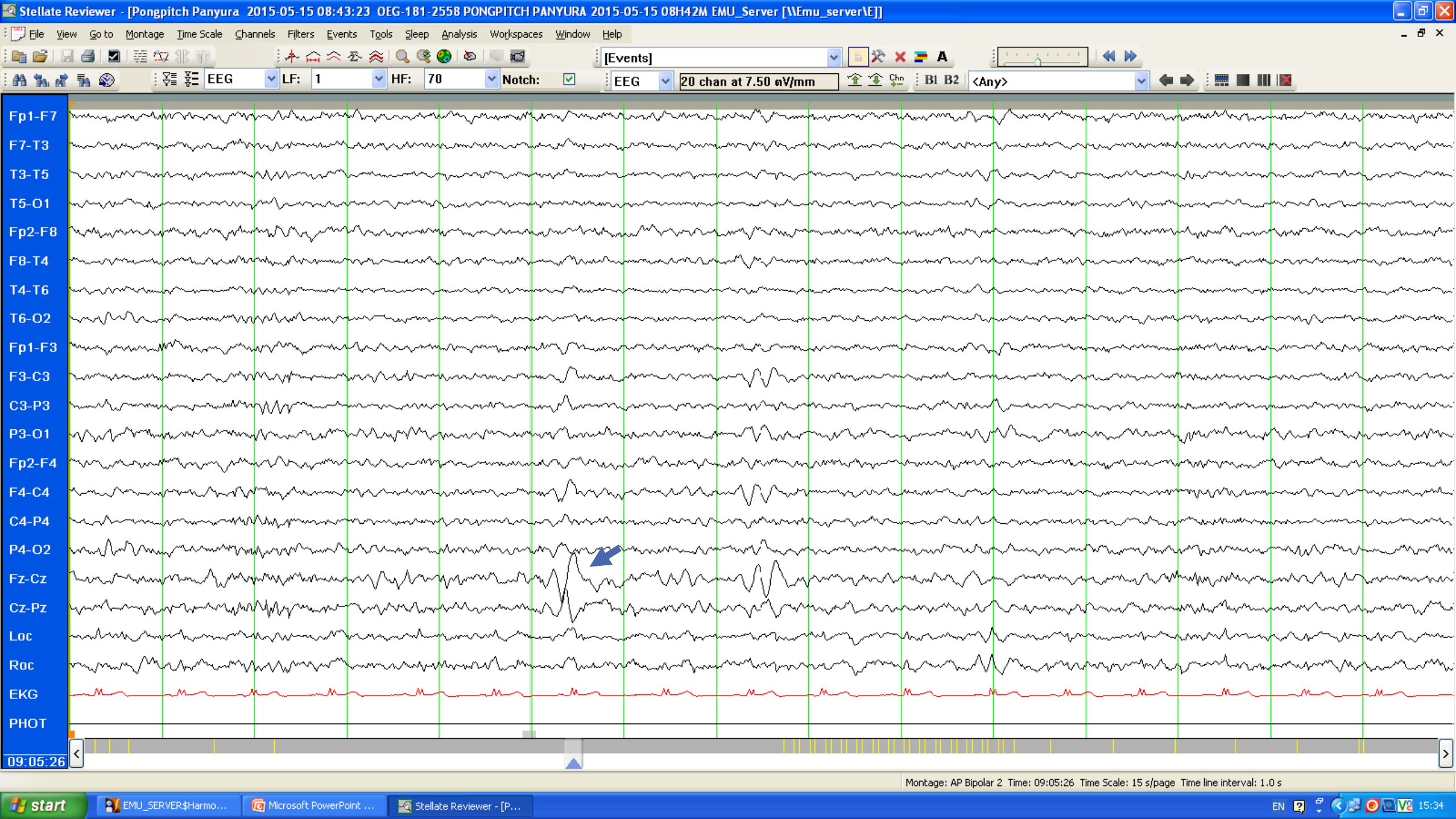

Stellate Reviewer - [Samita Anantarujakul 2014-09-16 08:40:33 OEG-469-2557 SAMITA ANANTARUJAKUL 2014-09-16 08H15M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 10.00 uV/mm
B1 B2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
Drowsy EEG (stage I NREM)
Waning of posterior alha rhythm
09:15:54
Montage: AP Bipolar 2 Time: 09:15:54 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Stellate Reviewer - [S...
Microsoft PowerPoint ...
EN
15:01


Stellate Reviewer - [Malee Sungsiri 2014-09-12 08:54:12 OEG-464-2557 MALEE SUNGSIRI 2014-09-12 08H53M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2 <Any>
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
09:20:16
POSTS
Drowsy EEG (stage I NREM)
POSTS (positive occipital sharp transient of sleep_
Montage: AP Bipolar 2 Time: 09:20:16 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Microsoft PowerPoint ...
Stellate Reviewer - [...
EN
15:18


Stellate Reviewer - [Malee Sungsiri 2014-09-12 08:54:12 OEG-464-2557 MALEE SUNGSIRI 2014-09-12 08H53M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2 <Any>
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
Sleep stage II
NREM
- Vertex waves
- Sleep spindles
- K-complexes
Sleep spindles
Vertex waves
09:18:36
Montage: AP Bipolar 2 Time: 09:18:36 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Microsoft PowerPoint ...
Stellate Reviewer - [...
EN
15:14


Stellate Reviewer - [Somthawil Chantharat 2015-04-09 10:07:26 OEG-144-2558 SOMTHAWIL CHANTHARAT 2015-04-09 10H06M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2 <Any>
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
K-complexes
10:32:42
Go to 08:52:32.338
start
EMU_SERVER$Harmo...
Microsoft PowerPoint ...
Stellate Reviewer - [S...
EN
17:00


Stellate Reviewer - [Malee Sungsiri 2014-09-12 08:54:12 OEG-464-2557 MALEE SUNGSIRI 2014-09-12 08H53M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2 <Any>
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
09:18:53
Montage: AP Bipolar 2 Time: 09:18:53 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Microsoft PowerPoint ...
Stellate Reviewer - [...
EN
15:14


Stellate Reviewer - [Pongpitch Panyura 2015-05-15 08:43:23 OEG-181-2558 PONGPITCH PANYURA 2015-05-15 08H42M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2 <Any>
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
09:05:26
Montage: AP Bipolar 2 Time: 09:05:26 Time Scale: 15 s/page Time line interval: 1.0 s
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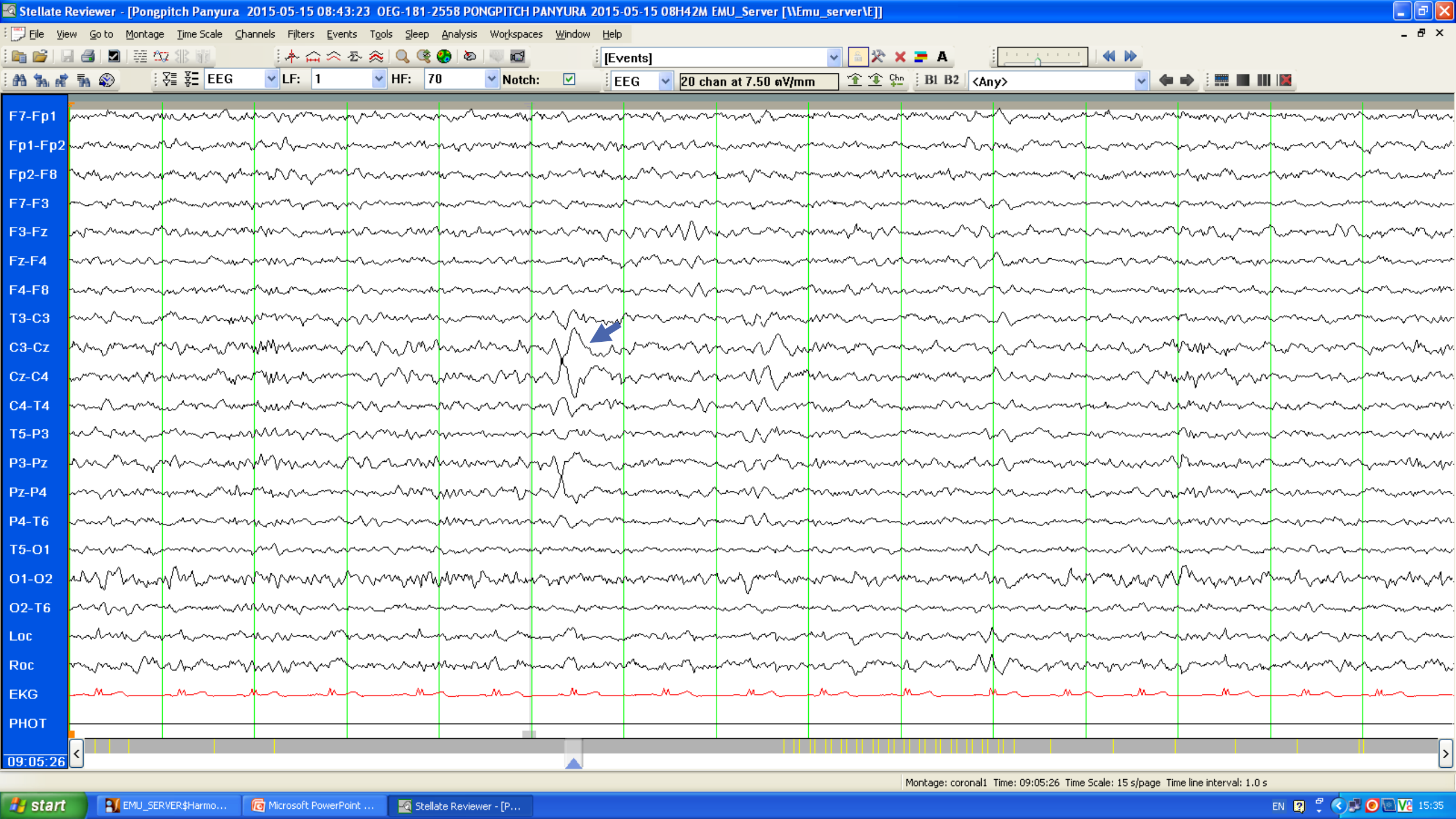
Microsoft PowerPoint ...
Stellate Reviewer - [P...
EN
15:34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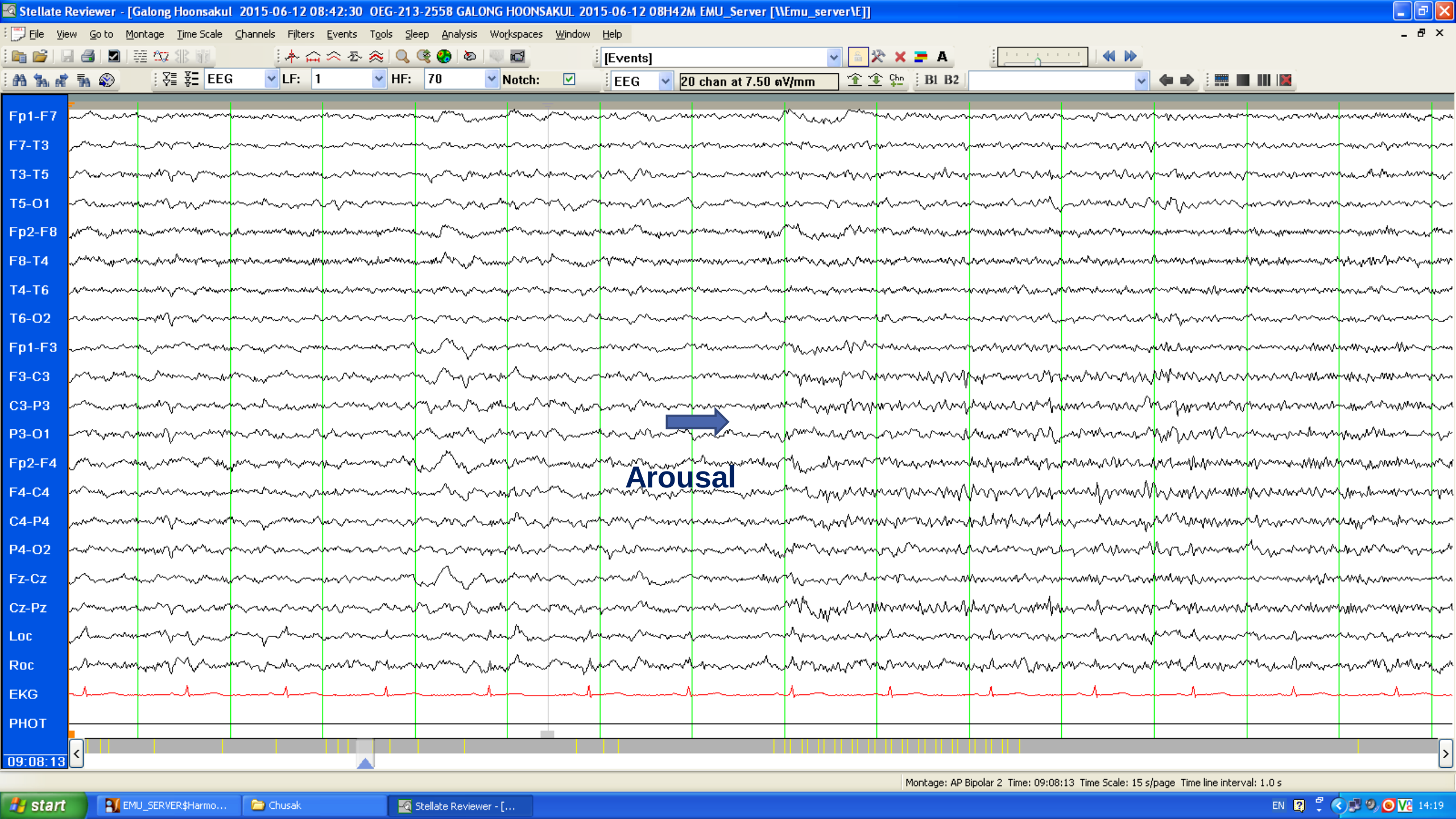
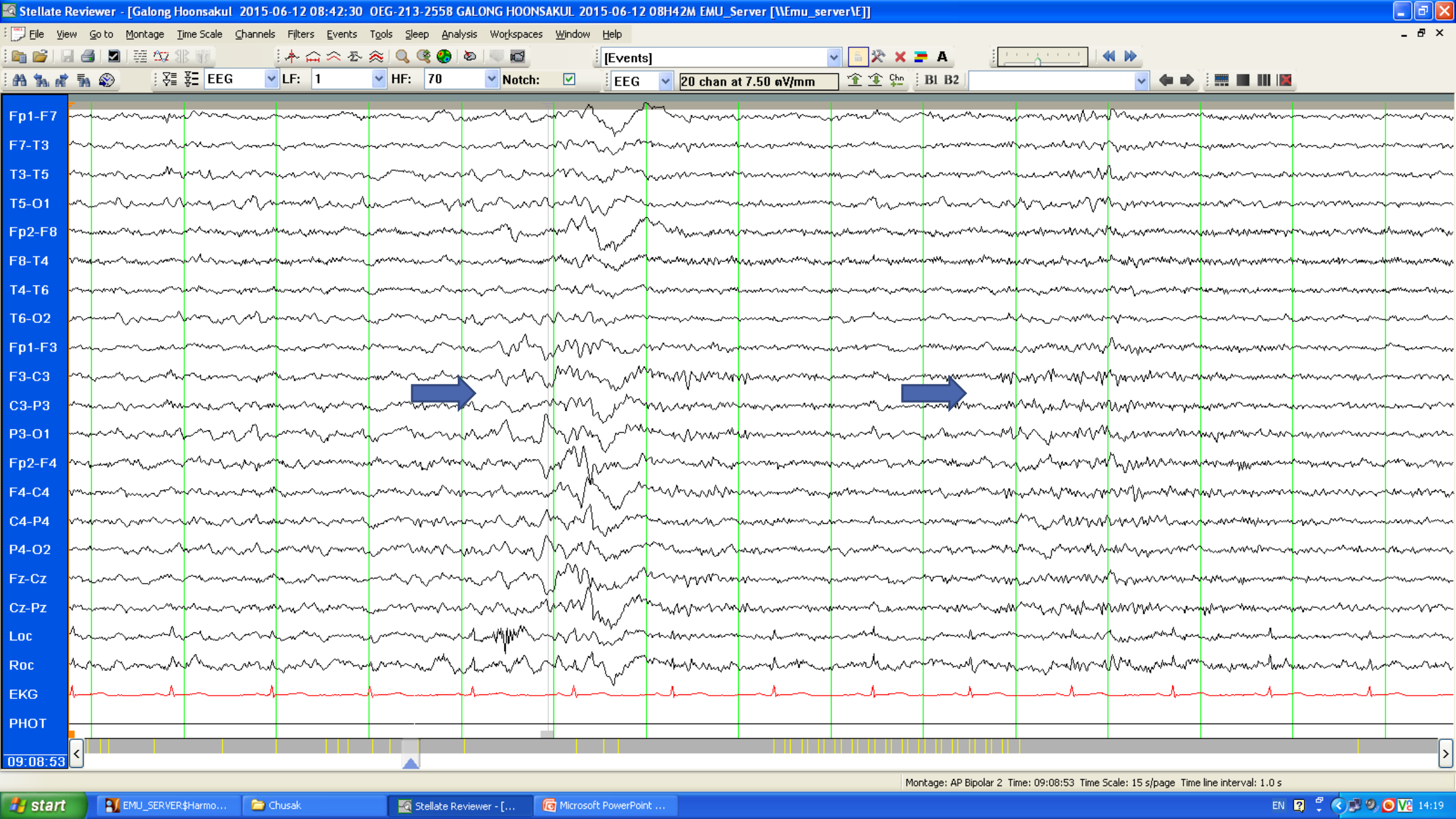
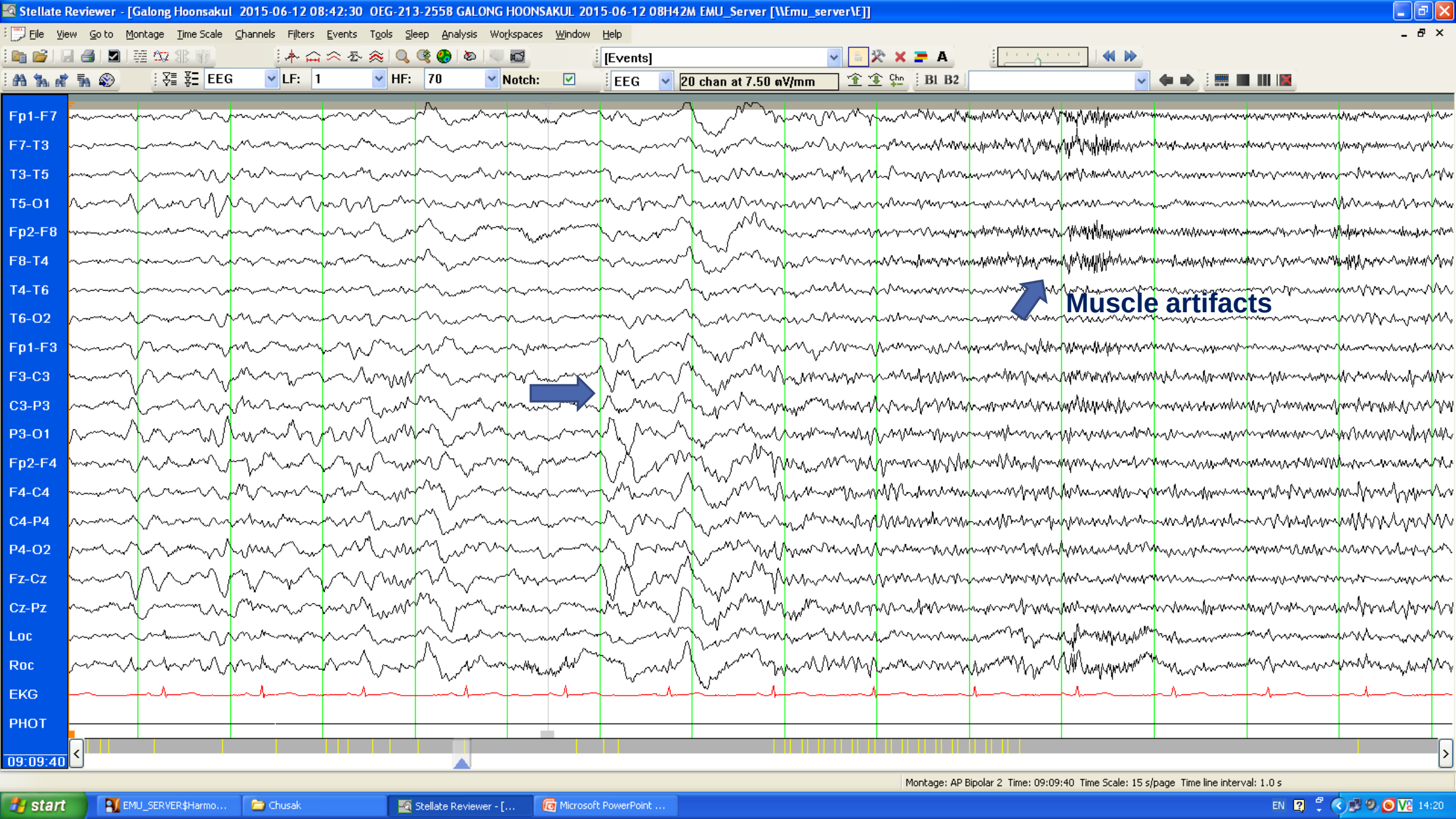
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2 <Any>
F7-Fp1
Fp1-Fp2
Fp2-F8
F7-F3
F3-Fz
Fz-F4
F4-F8
T3-C3
C3-Cz
Cz-C4
C4-T4
T5-P3
P3-Pz
Pz-P4
P4-T6
T5-O1
O1-O2
O2-T6
Loc
Roc
EKG
PHOT
09:05:26
Montage: coronal1 Time: 09:05:26 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Microsoft PowerPoint ...
Stellate Reviewer - [P...
EN
15:35


Stellate Reviewer - [Galong Hoonsakul 2015-06-12 08:42:30 OEG-213-2558 GALONG HOONSAKUL 2015-06-12 08H42M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
Arousal
09:08:13
Montage: AP Bipolar 2 Time: 09:08:13 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Chusak
Stellate Reviewer - [...
EN
14:19


Stellate Reviewer - [Galong Hoonsakul 2015-06-12 08:42:30 OEG-213-2558 GALONG HOONSAKUL 2015-06-12 08H42M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
09:08:53
Montage: AP Bipolar 2 Time: 09:08:53 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Chusak
Stellate Reviewer - [...
Microsoft PowerPoint ...
EN
14:19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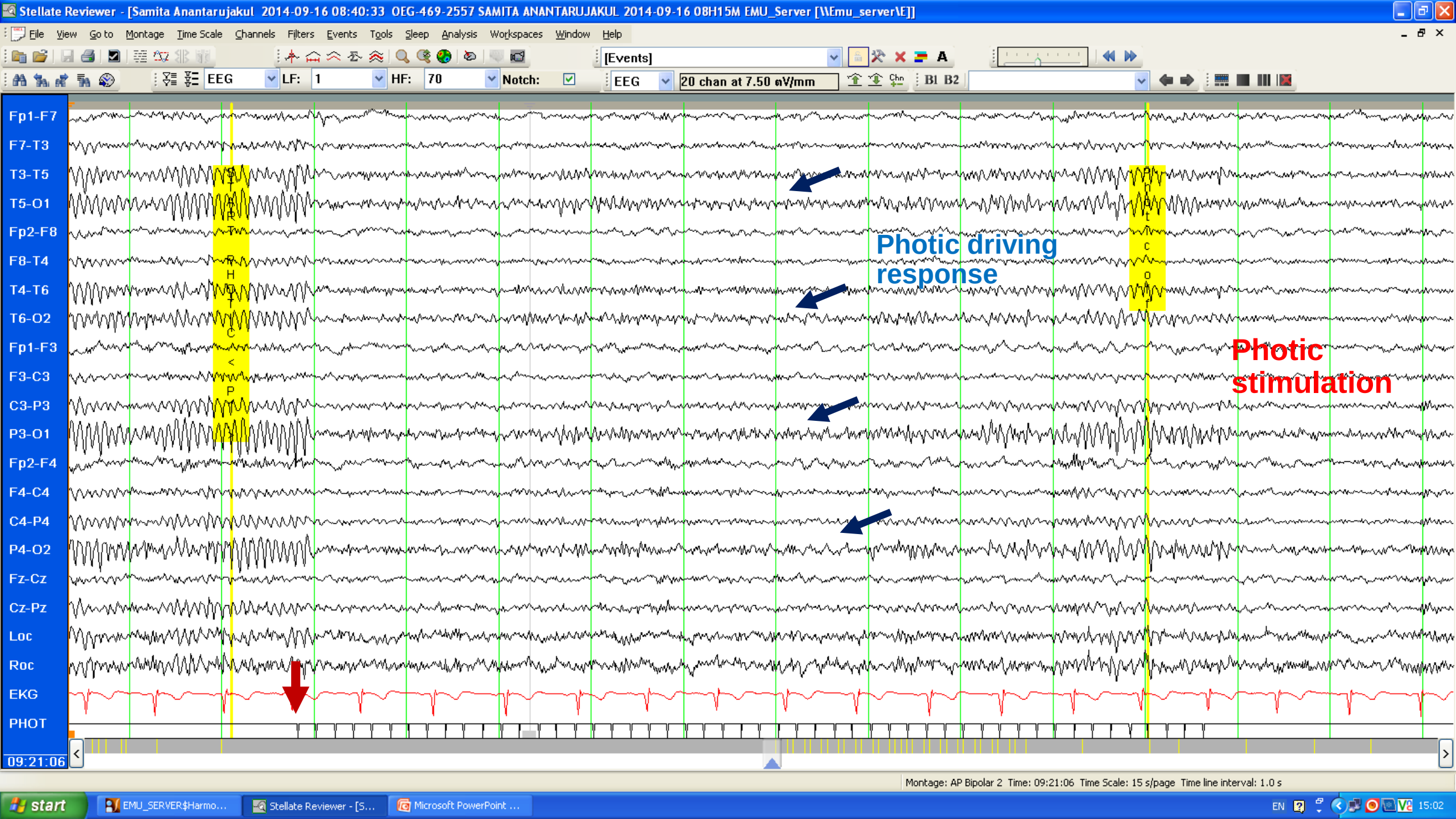
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
Muscle artifacts
09:09:40
Montage: AP Bipolar 2 Time: 09:09:40 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Chusak
Stellate Reviewer - [...
Microsoft PowerPoint ...
EN
14:20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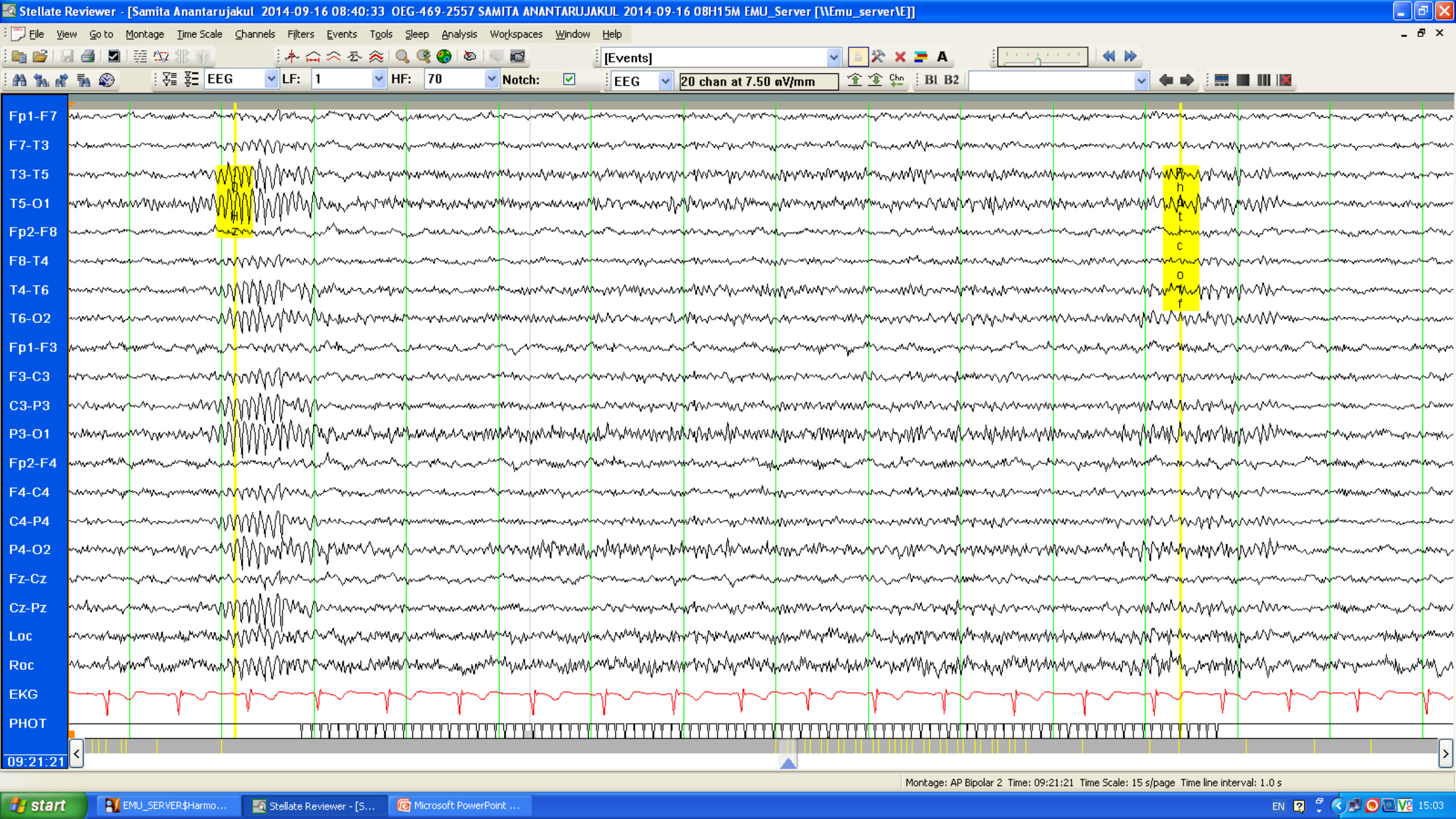
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
Photic driving response
Photic stimulation
09:21:06
Montage: AP Bipolar 2 Time: 09:21:06 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Stellate Reviewer - [S...
Microsoft PowerPoint ...
EN
15:02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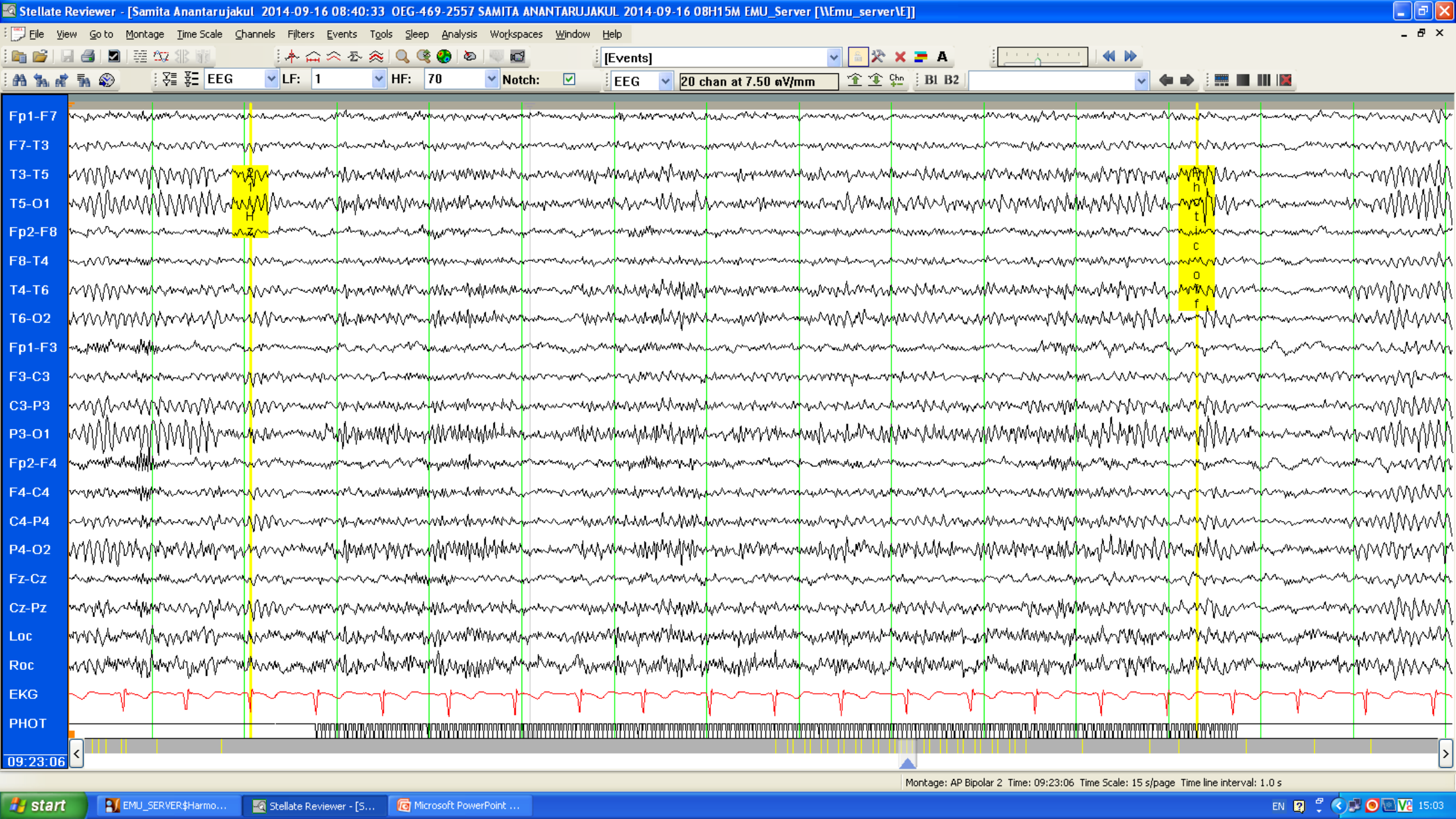
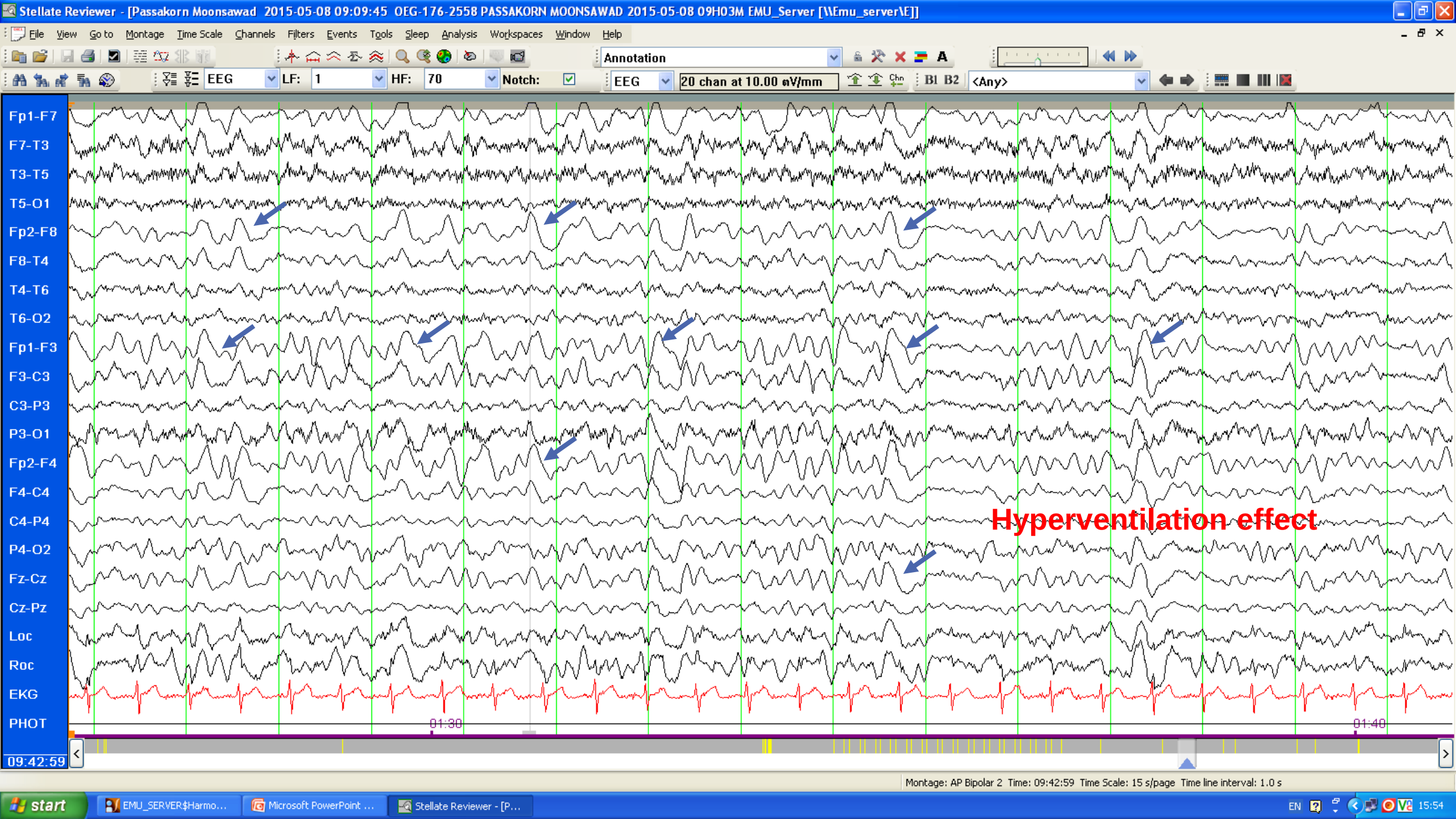
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
09:21:21
Montage: AP Bipolar 2 Time: 09:21:21 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Stellate Reviewer - [S...
Microsoft PowerPoint ...
EN
15:03


Stellate Reviewer - [Samita Anantarujakul 2014-09-16 08:40:33 OEG-469-2557 SAMITA ANANTARUJAKUL 2014-09-16 08H15M EMU_Server [\\Emu_server\E]]
File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
[Events]
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 7.50 uV/mm
B1 B2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
09:23:06
Montage: AP Bipolar 2 Time: 09:23:06 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Stellate Reviewer - [S...
Microsoft PowerPoint ...
EN
15:03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File View Go to Montage Time Scale Channels Filters Events Tools Sleep Analysis Workspaces Window Help
Annotation
EEG LF: 1 HF: 70 Notch:
EEG 20 chan at 10.00 uV/mm
B1 B2 <Any>
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fz-Cz
Cz-Pz
Loc
Roc
EKG
PHOT
01:30
01:40
09:42:59
Hyperventilation effect
Montage: AP Bipolar 2 Time: 09:42:59 Time Scale: 15 s/page Time line interval: 1.0 s
start
EMU_SERVER$Harmo...
Microsoft PowerPoint ...
Stellate Reviewer - [P...
EN
15:54

THANK YOU FOR YOUR ATTENTION