


Artifacts & Normal Variants
Basic EEG Course

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Kullasate Sakpichaisakul, MD

Division of Neurology, Department of Pediatrics

Queen Sirikit National Institute of Child Health

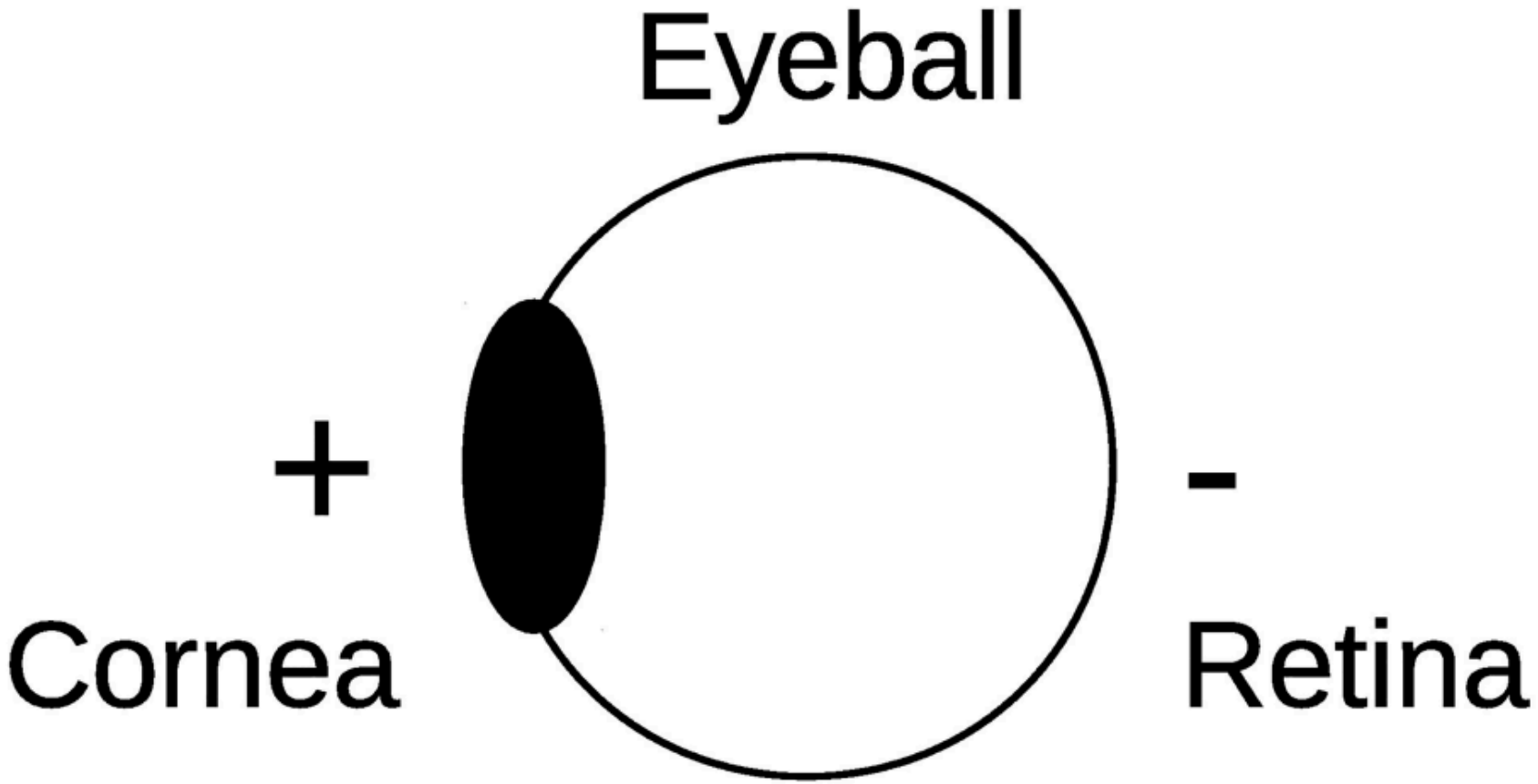
Learning Objectives

- To identify the definition and types of artifacts
- To identify common normal variants

Artifacts

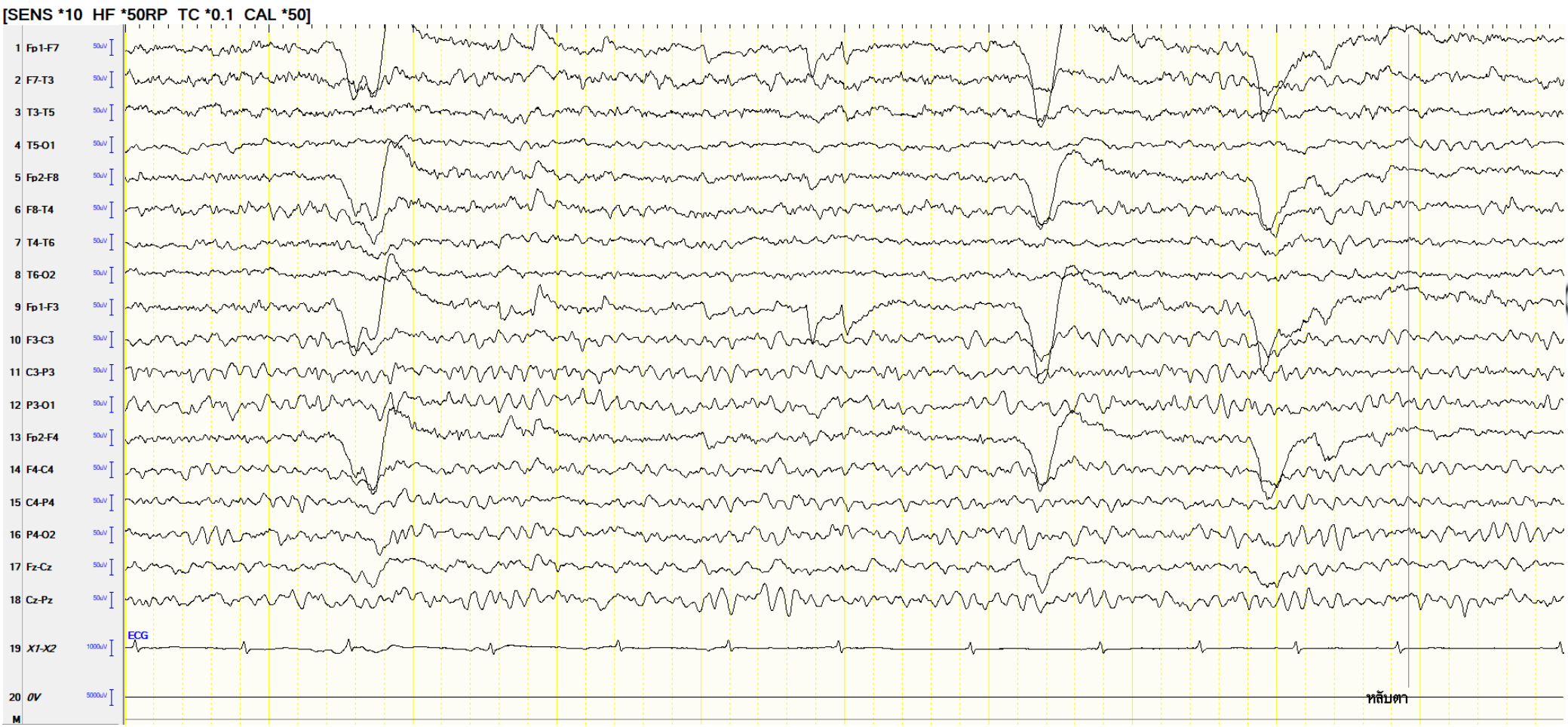
- Unwanted electrical activity arising from different sources, other than cerebral activity
- Physiolocial/ biological artifacts:
  - Artifacts from the eyes and eyelids: Eye movement or blink artifacts
  - Tongue movement artifacts: glossokinetic, chewing, swallowing
  - EMG
  - ECG
- Nonphysiological artifacts: from electical phonemena or devices in the recording environment

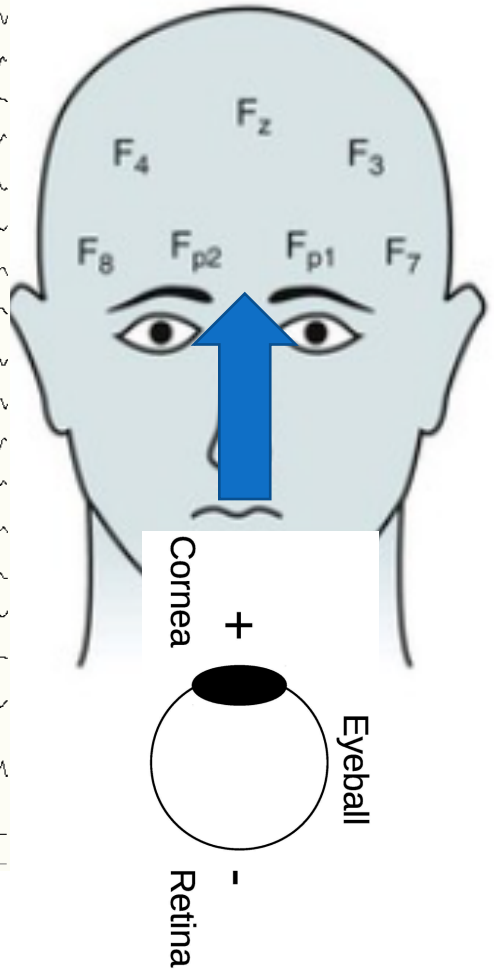
Corneoretinal Potential



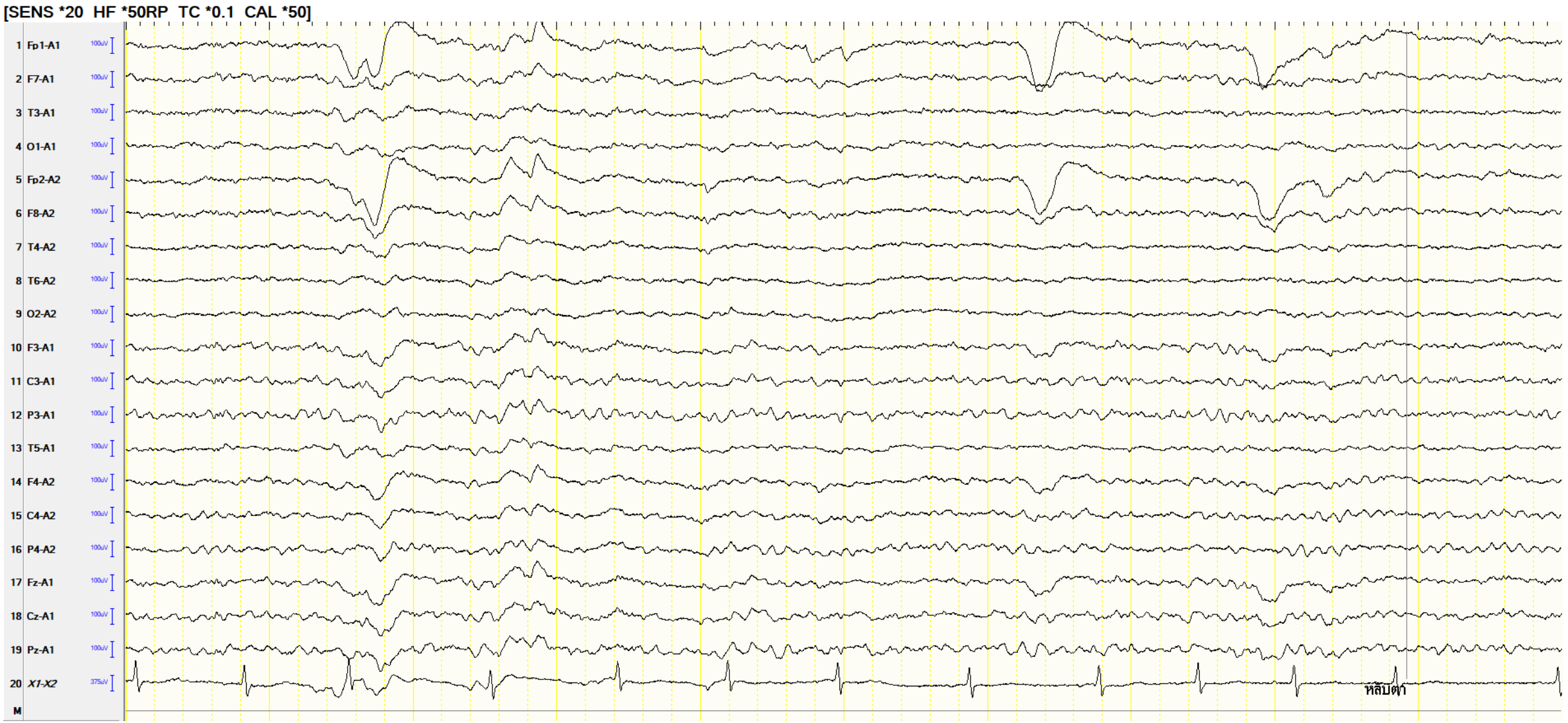
Fang F & Shinozaki T, PLoS One 2018

Blink Artifact

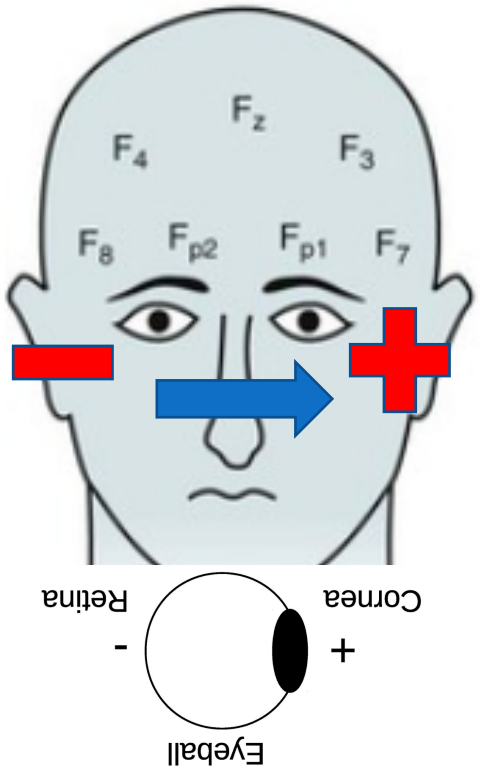




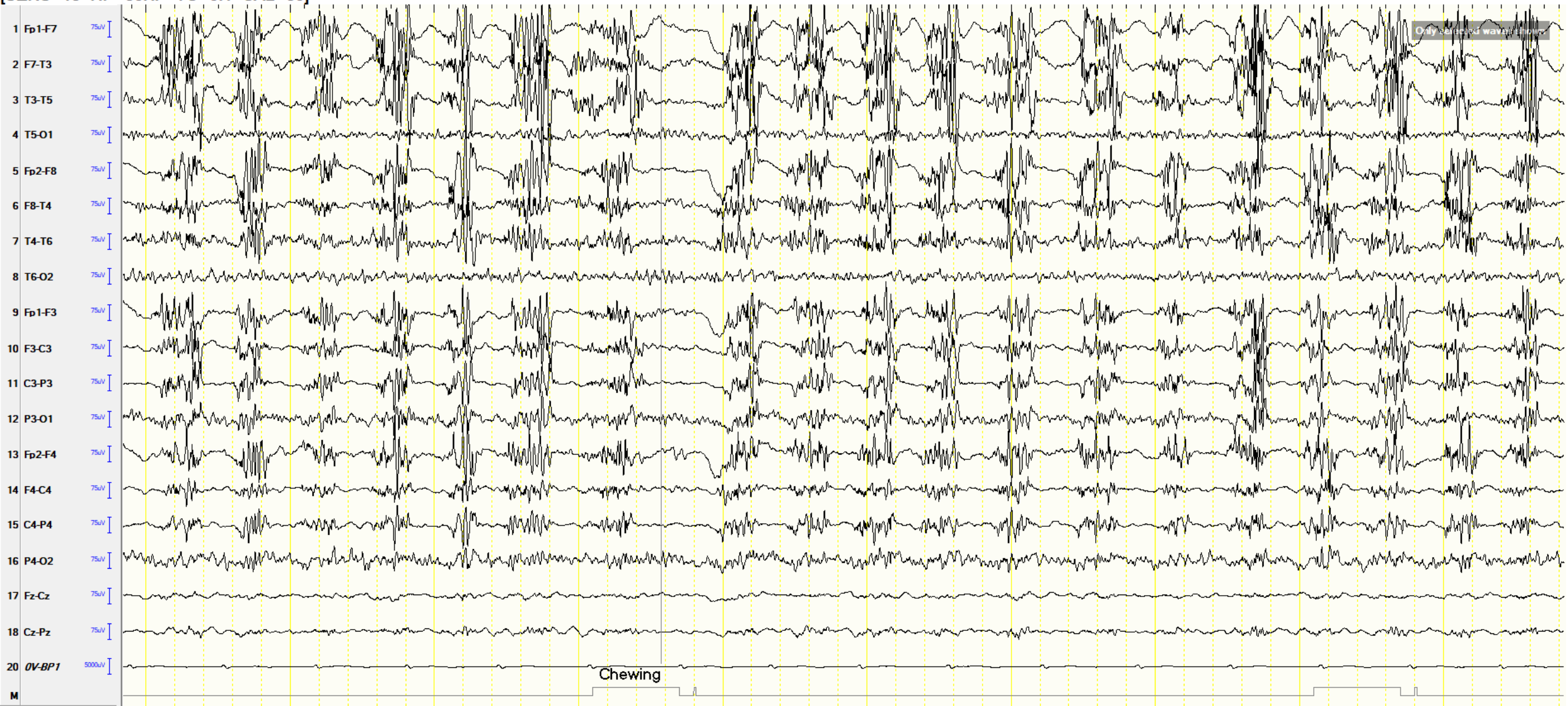
Blink Artifact



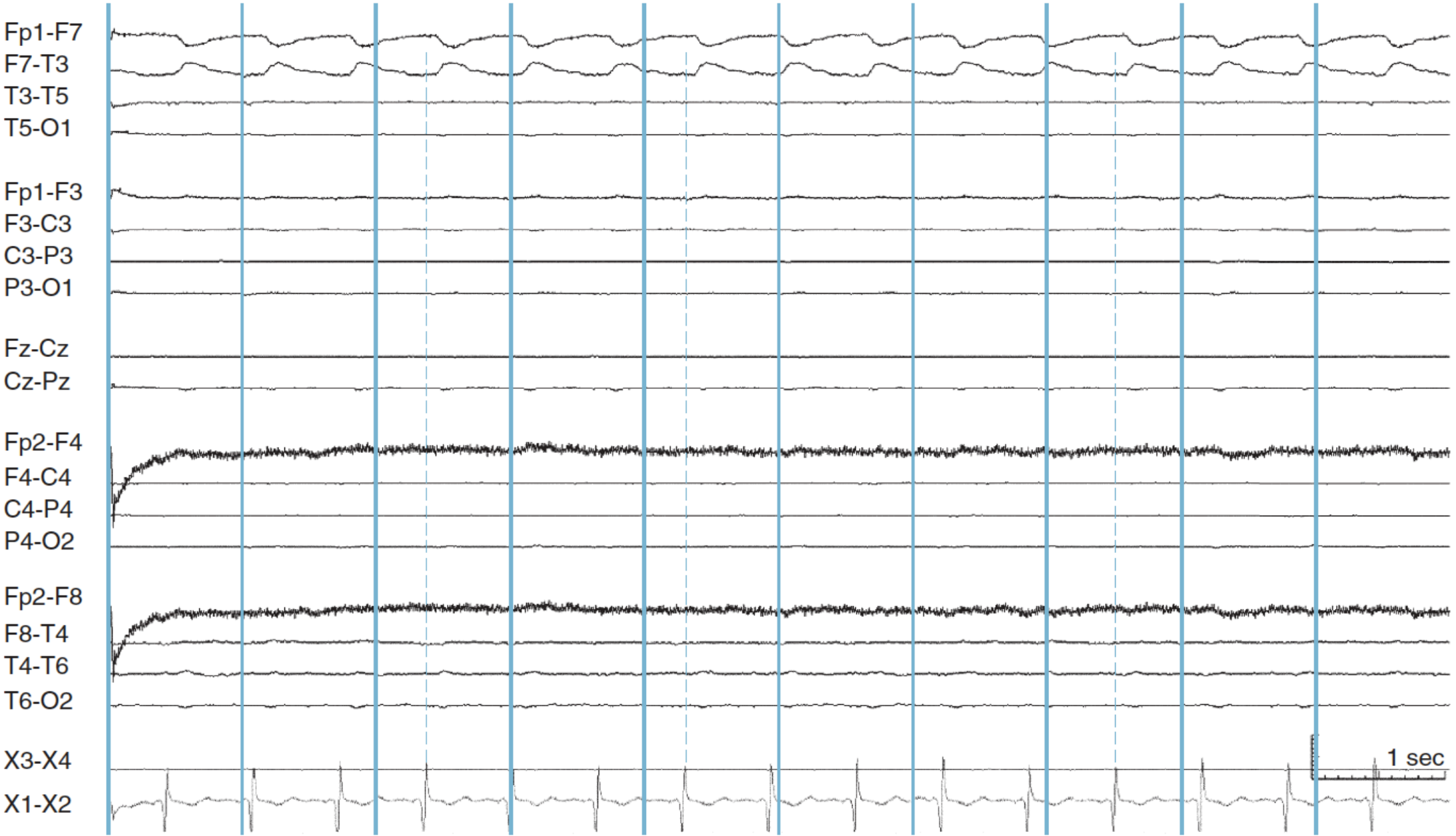
Left Lateral Eye Movement



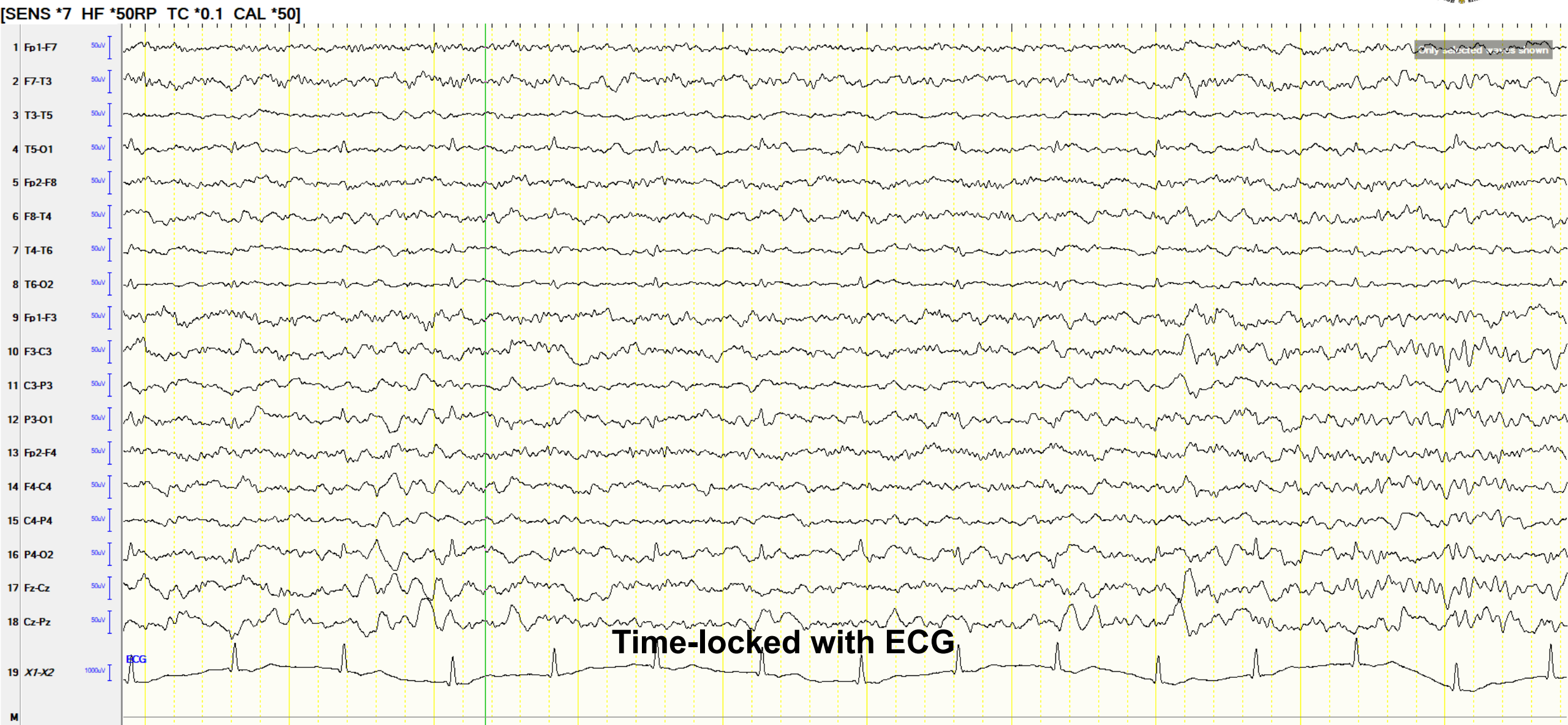
Chewing Artifact



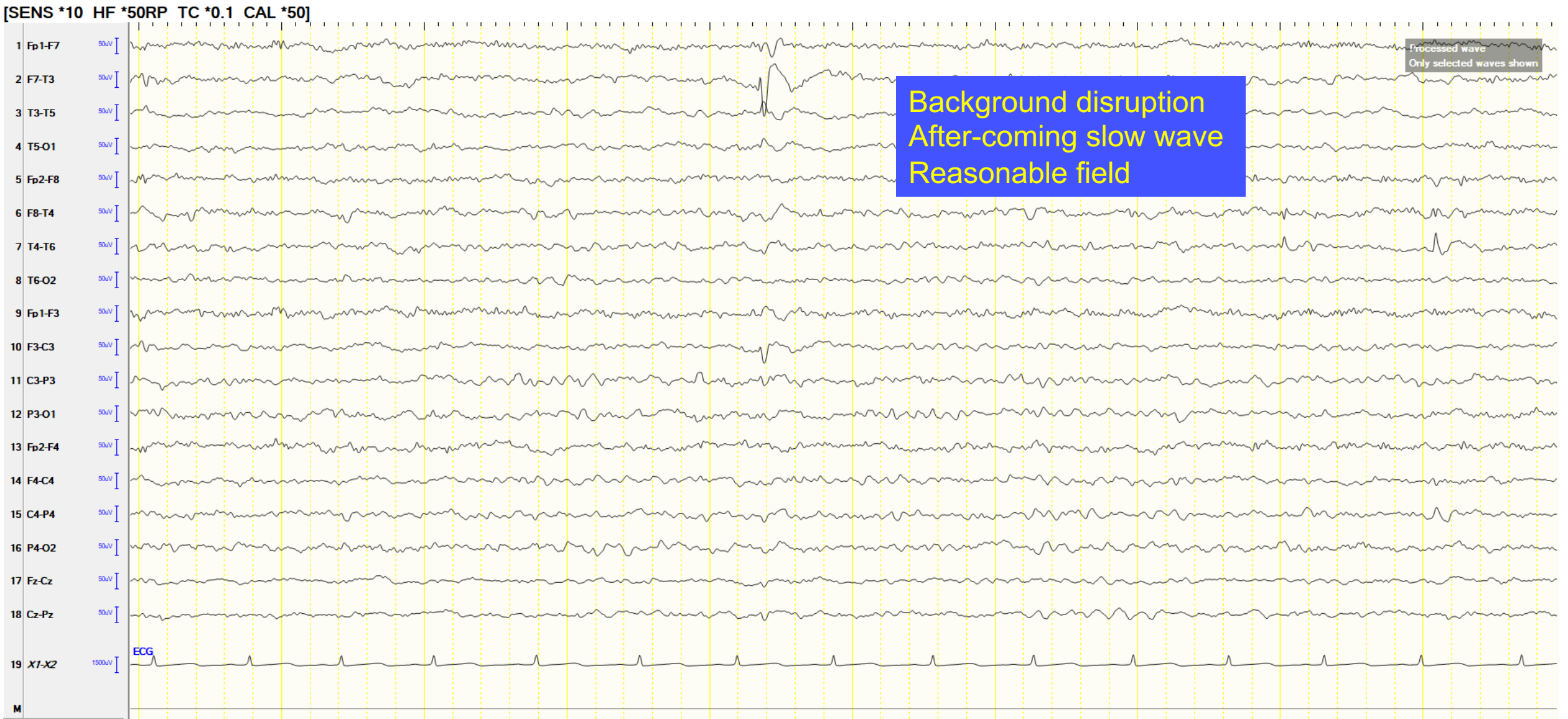
Pulse Artifact



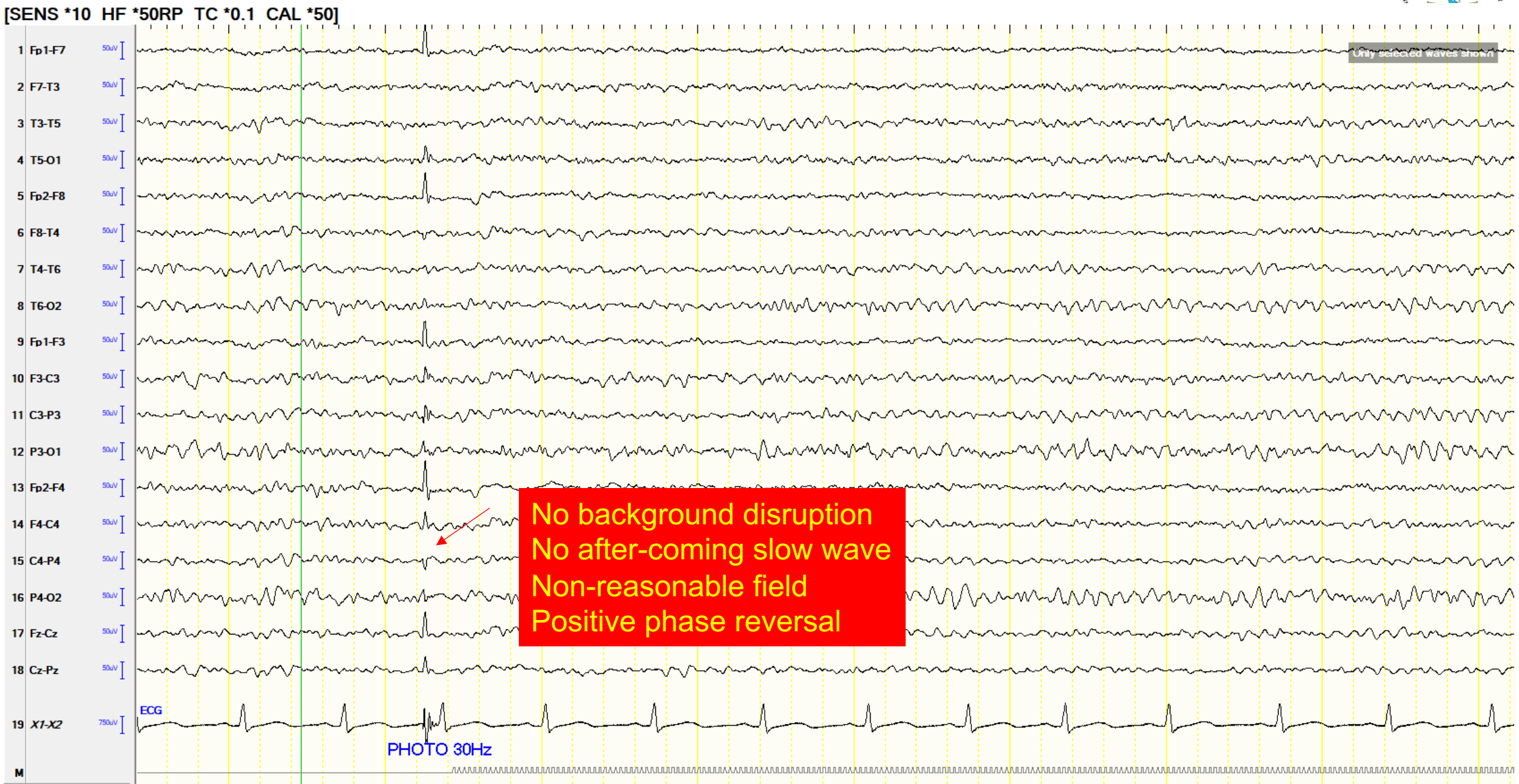
ECG Artifact



True Spike-Left Temporal



Artifact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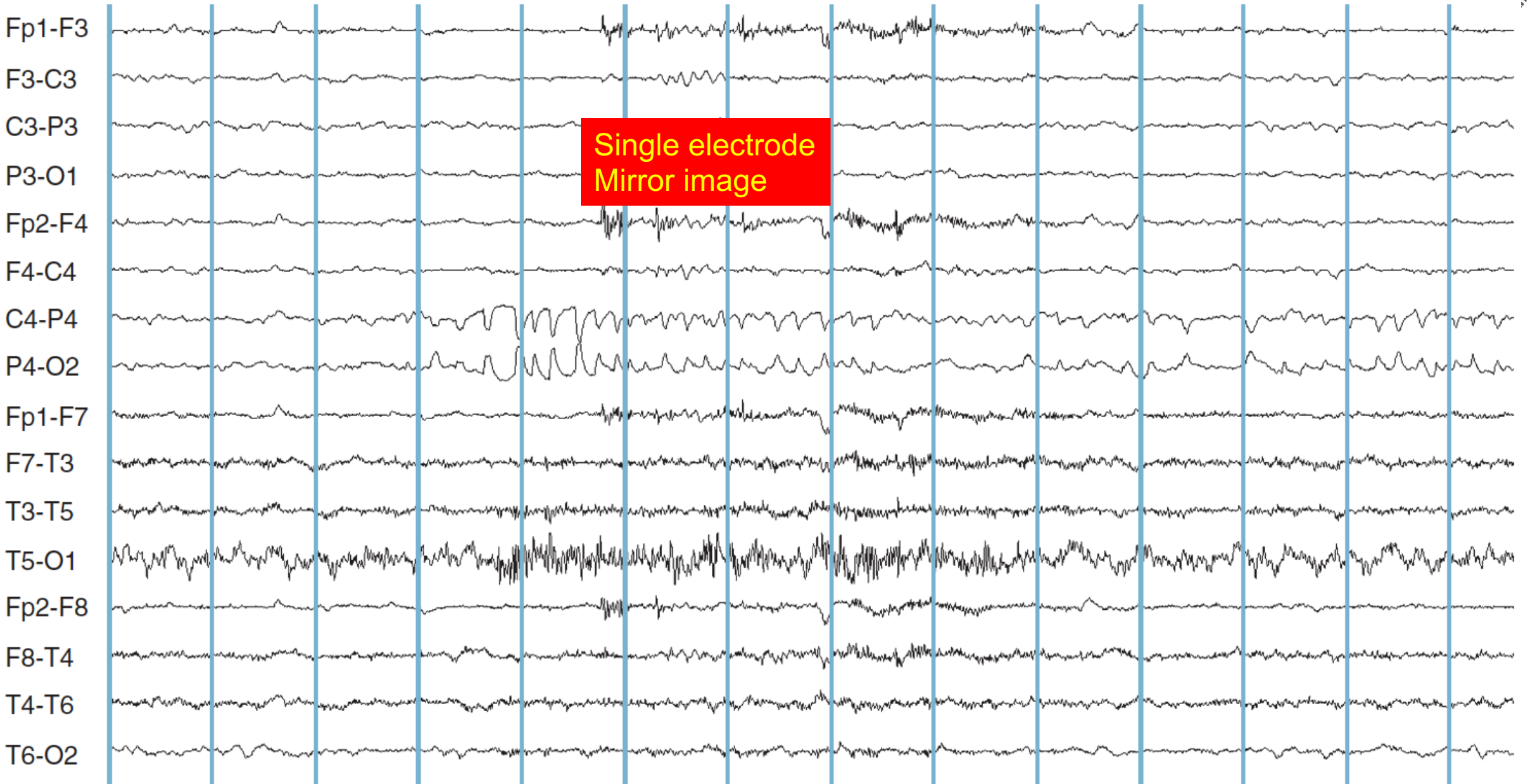
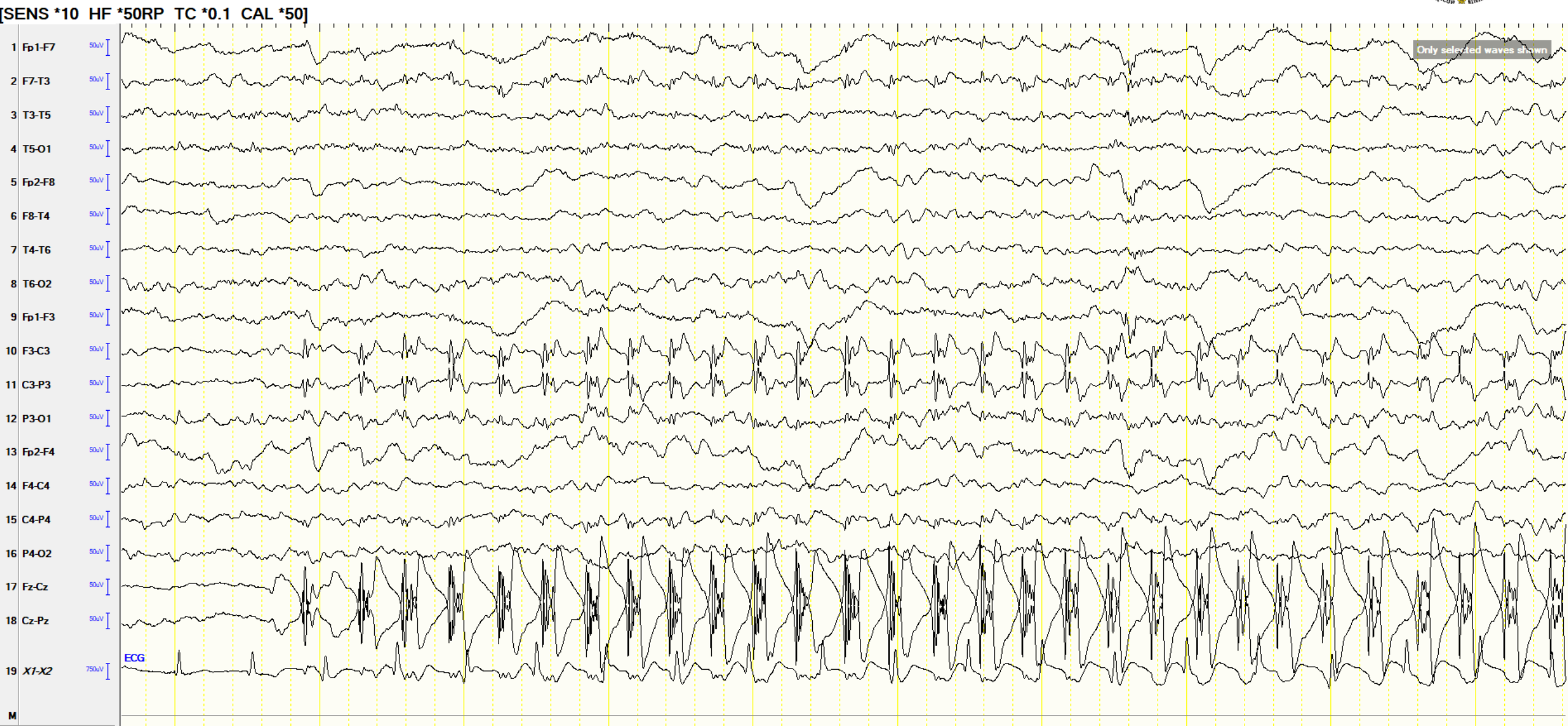
1 Fp1-F7
2 F7-T3
3 T3-T5
4 T5-O1
5 Fp2-F8
6 F8-T4
7 T4-T6
8 T6-O2
9 Fp1-F3
10 F3-C3
11 C3-P3
12 P3-O1
13 Fp2-F4
14 F4-C4
15 C4-P4
16 P4-O2
17 Fz-Cz
18 Cz-Pz
19 X1-X2
M
50uV
750uV
Only selected waves shown
ECG
PHOTO 30Hz
No background disruption
No after-coming slow wave
Non-reasonable field
Positive phase reversal

Electrode “pop” Artifact



Patting Artifact



Normal Variants

- Rhythms or waveforms that have features reminiscent of either interictal or ictal EEG abnormalities
- Found in a substantial proportion of healthy subjects
- NOT representing pathological entities

Normal Variants Patterns

1. Rhythmic patterns
2. Epileptiform patterns
3. Lambda and lambdoids
4. Age related variants

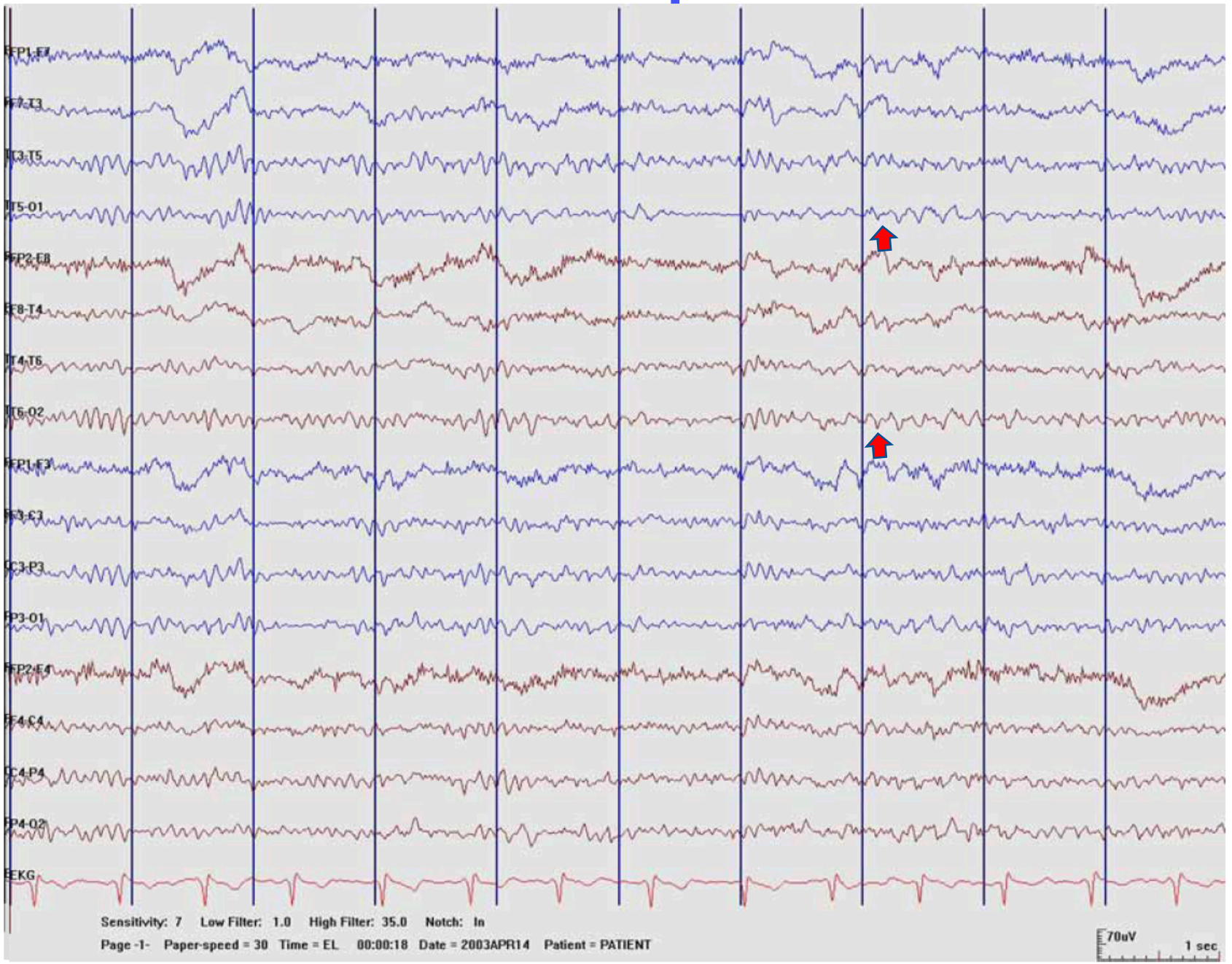
Normal Variants Patterns

1. Rhythmic patterns
   - Alpha variant
   - Mu rhythm
   - Rhythmic mid-temporal burst of drowsiness (RMTD)
   - Subclinical rhythmic electrographic discharges in adults (SREDA)
   - Midline theta rhythm
   - Frontal arousal rhythm
2. Epileptiform patterns
3. Lambda and lambdoids
4. Age related variants

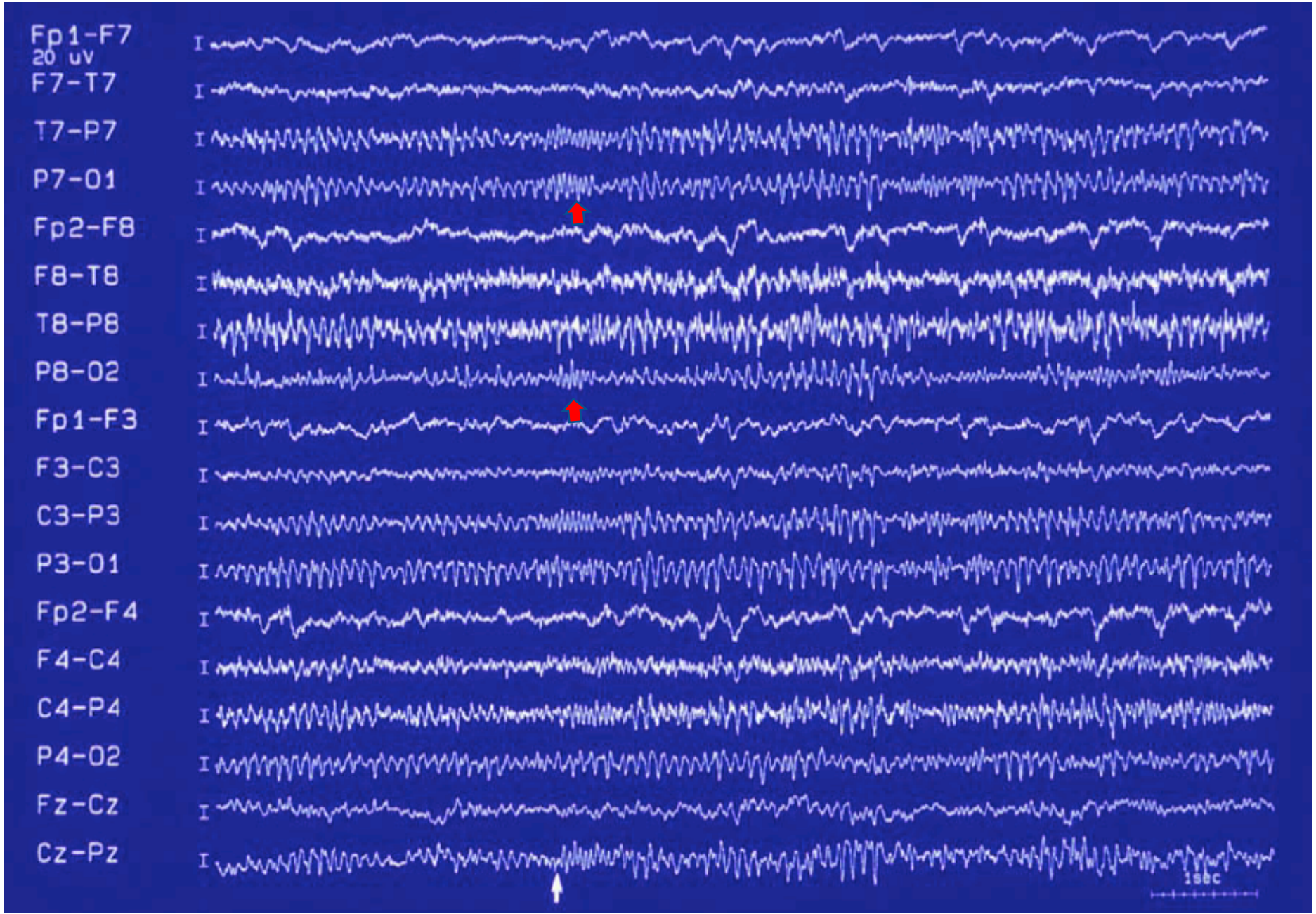
Alpha Variant

- “Slow/ Subharmonic”: half frequency of the patient’s PDR
- “Fast/ Supraharmonic”: twice of the PDR frequency
- **Location:** Posterior head regions (O1, O2)
- **State:** awake
- Blocked by eye opening

Subharmonic Alpha Variant



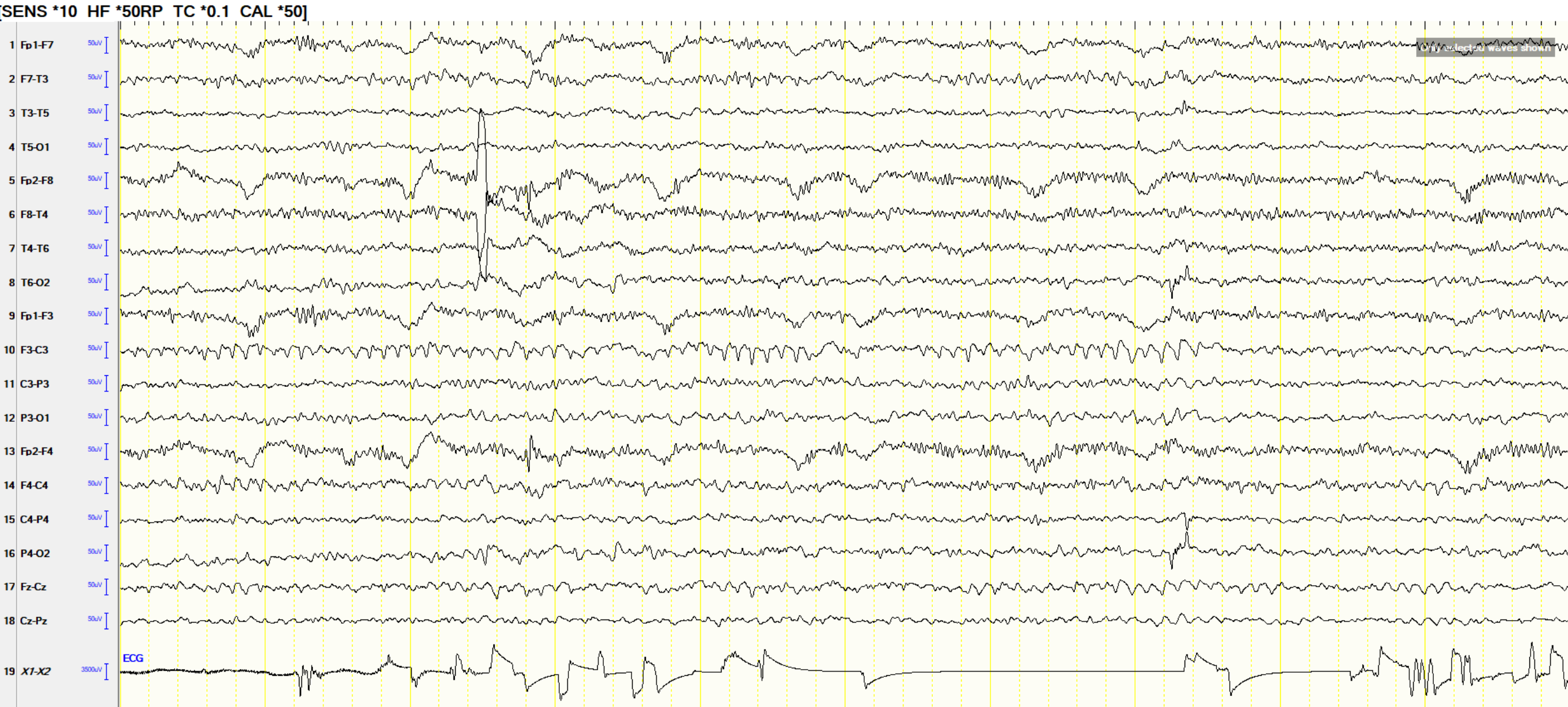
Supraharmonic Alpha Variant



Mu Rhythm

- "μ" = "motor"
- Associated with sensorimotor cortex
- **Morphology:** comb, arc
- **Frequency:** 9-11 Hz
- **Location:** Central (C3, C4, and Cz)
- **State:** wakeful
- Blocked by contralatral limb movement

Mu Rhythm


[SENS *10 HF *50RP TC *0.1 CAL *50]
1 Fp1-F7
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5 Fp2-F8
6 F8-T4
7 T4-T6
8 T6-O2
9 Fp1-F3
10 F3-C3
11 C3-P3
12 P3-O1
13 Fp2-F4
14 F4-C4
15 C4-P4
16 P4-O2
17 Fz-Cz
18 Cz-Pz
19 X1-X2
50uV
3500uV
ECG

Rhythmic Mid-Temporal Burst of Drowsiness (RMTD)

- Psychomotor variants
- **Morphology:** monomorphic, flat-topped or notched
- **Frequency:** 5-7 Hz (Theta)
- **Location:** Mid-temporal (T3, T4)
- **State:** drowsy, light sleep
- Disappears during deepening sleep
- Do NOT evolve or spread to other sites
- Found in adolescents and young adults

Rhythmic Mid-Temporal Burst of Drowsiness (RMTD)

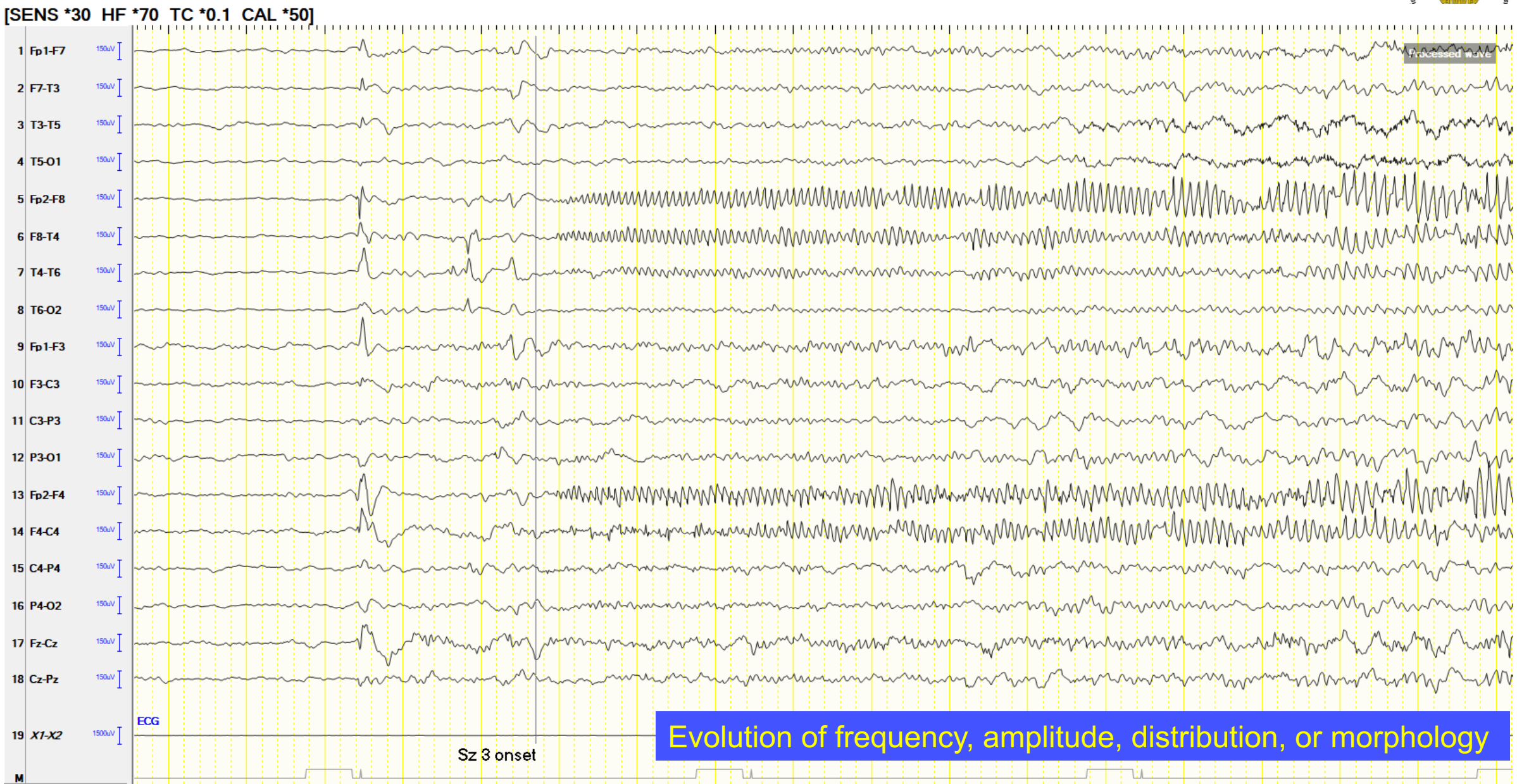
Subclinical Rhythmic Electrographic Discharges in Adults (SREDA)

- **Morphology:** sharply contoured
- **Frequency:** 5-7 Hz (Theta)
- **Location:** Temporo-parietal
- **State:** drowsy, during hyperventilation
- Mild frequency evolution BUT NO spatial or topographic evolution (e.g. spread to other sites)
- Abrupt offset
- Found in older adults

SREDA


Nz - F9
F9 - T9
T9 - P9
P9 - Iz
Fp1 - F7
F7 - T7
T7 - P7
P7 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T8
T8 - P8
P8 - O2
Nz - F10
F10 - T10
T10 - P10
P10 - Iz
ECG

Ictal Evolution



Midline Theta Rhythm

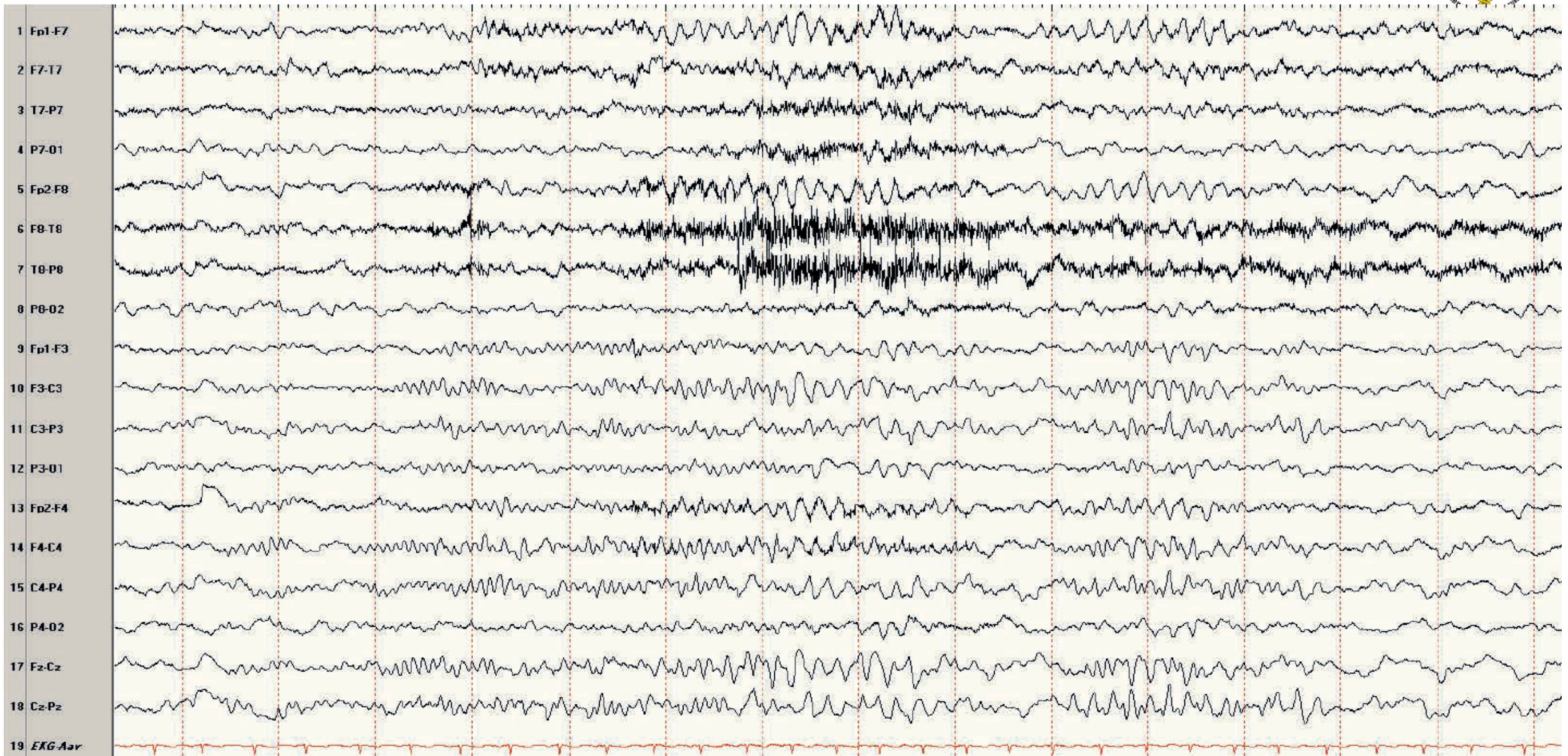
- **Morphology:** smooth, arc-shaped (mu-like), previously known as “Ciganek rhythm”
- **Frequency:** 5-7 Hz (Theta)
- **Location:** Mid-central (Cz)
- **State:** wakeful, drowsy
- Reacts to limb movements, alerting, and/or eye opening

Midline Theta Rhythm

Frontal Arousal Rhythm

- **Morphology:** notched appearance
- **Frequency:** 7-10 Hz
- **Location:** Frontal head regions
- **State:** sleep to wake transition
- Disappear when fully awake

Frontal Arousal Rhythm



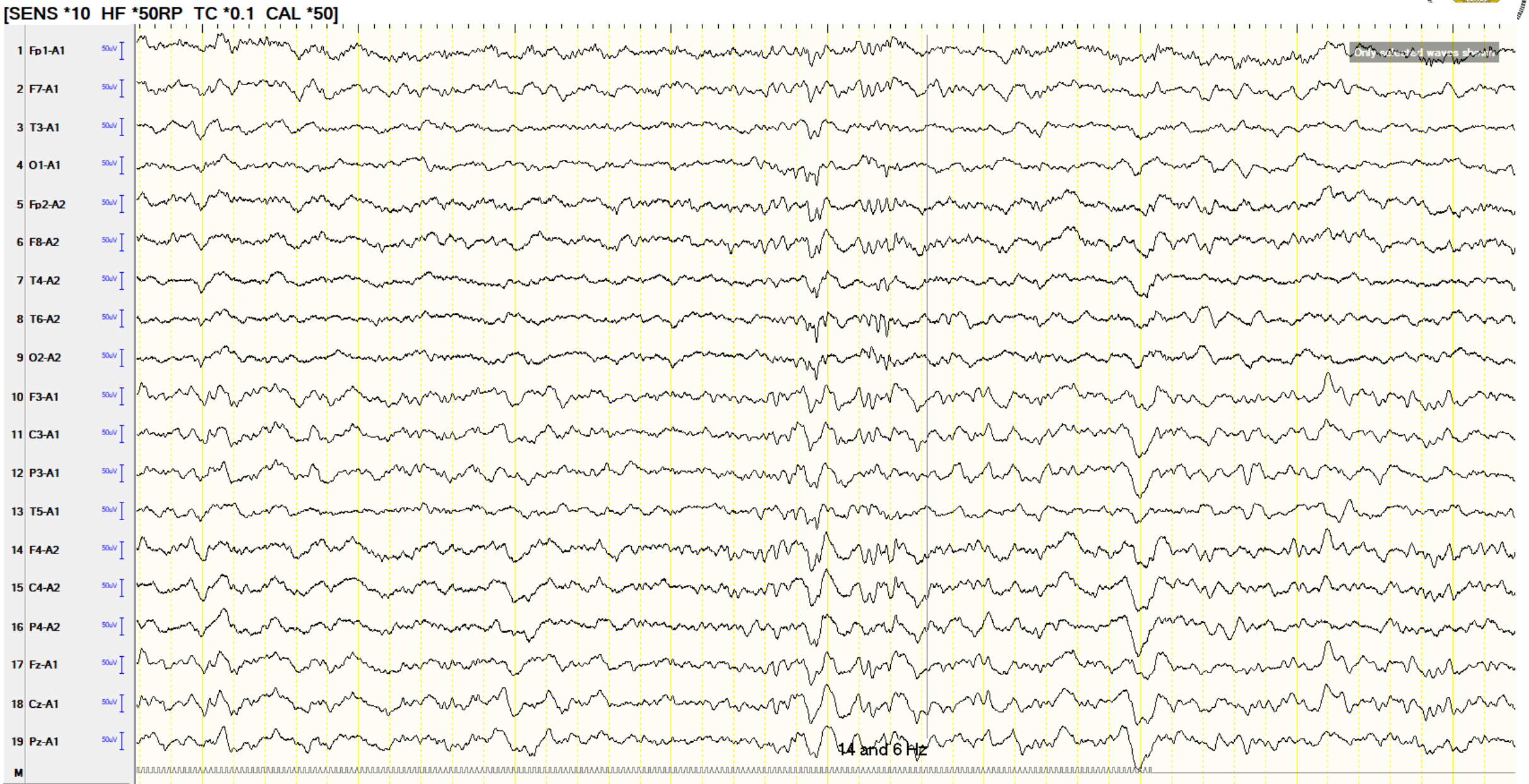
Normal Variants Patterns

1. Rhythmic patterns
2. Epileptiform patterns
   - 14 and 6 Hz positive bursts
   - Small sharp spikes (benign epileptiform transients of sleep: BETS)
   - 6-Hz spike and wave (phantom spike and wave)
   - Wicket spikes
3. Lambda and lambdoids
4. Age related variants

14 and 6 Hz Positive Bursts

- **Morphology:** burst of surface positive comb like spikes
- **Frequency:** 14 or 6 Hz
- **Location:** anterior/ mid-temporal
- **State:** drowsiness, light sleep
- Found in young infants (6 Hz), adolescents (14 Hz)
- Best seen with long interelectorde distances (e.g. ear references)

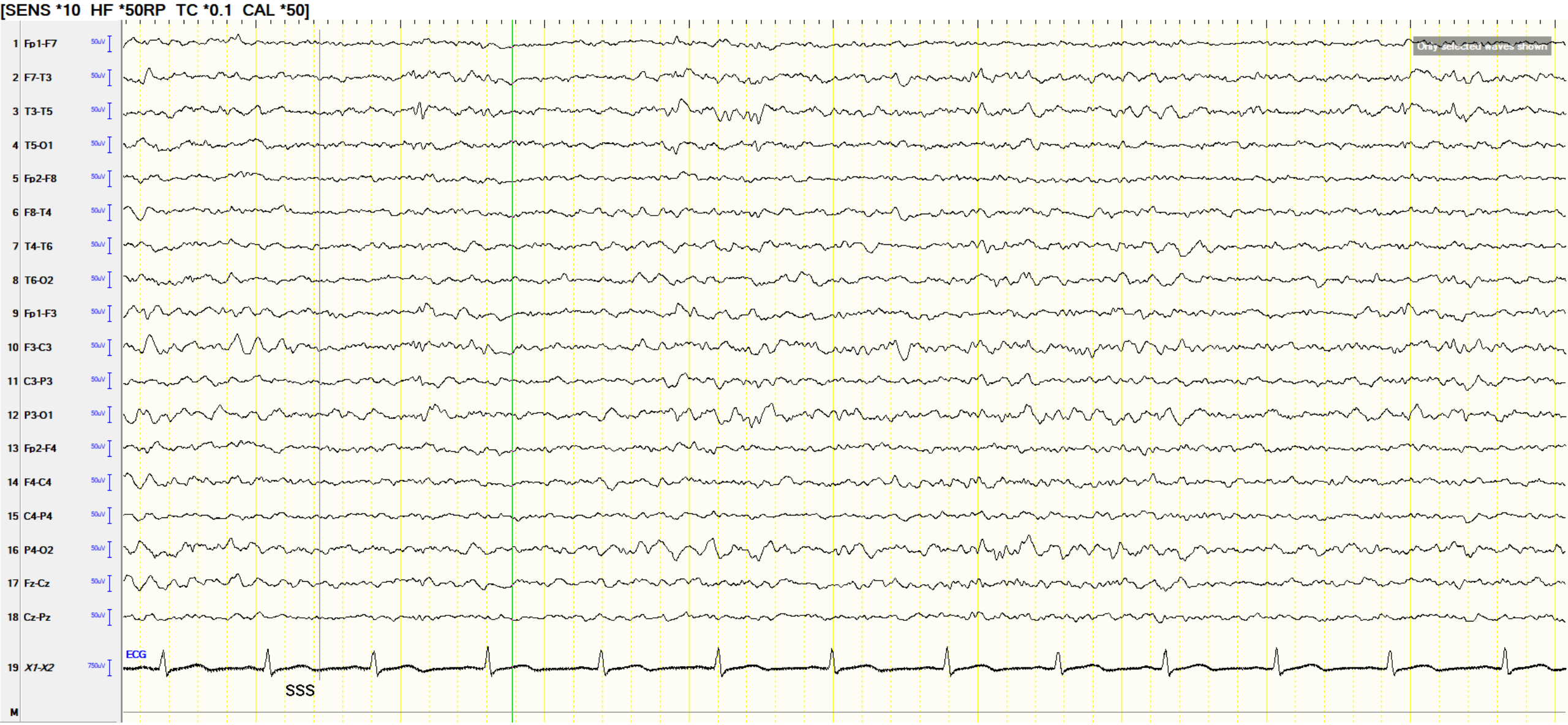
14 and 6 Hz Positive Bursts



Small Sharp Spikes (BETS)

- **Morphology:** low amplitude, brief duration, mono or biphasic
- **Location:** posterior temporal
- **State:** drowsiness, light sleep
- Found in adolescents and adults
- NOT run in trains, disruption of background, or coexisting with rhythmic slowing
- Disappears during deeper sleep stages

Small Sharp Spikes (BETS)

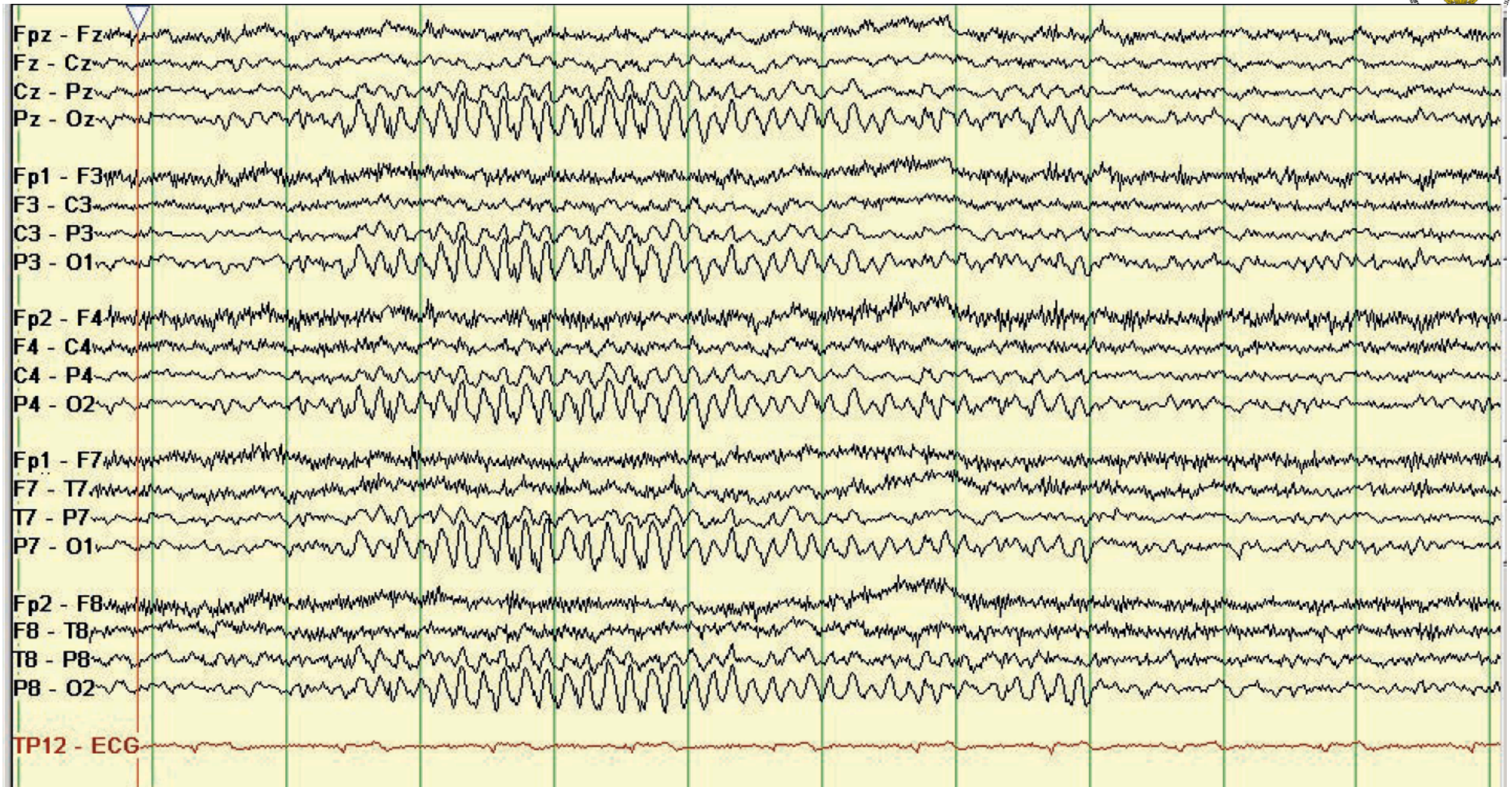


6-Hz Spike and Slow Wave
(Phantom spike and Wave)

- **Morphology:** mitten like with a very small spike and apparent slow wave
- **Location:** Anterior (WHAM) or Posterior (FOLD)
- **State:** Wakeful (WHAM) or Drowsiness (FOLD)
- Found in adolescents and adults
- NOT run in trains, NO disruption of background, or coexisting with rhythmic slowing
- Disappears during deeper sleep stages

Waking, High amplitude, Anterior, Male (WHAM)

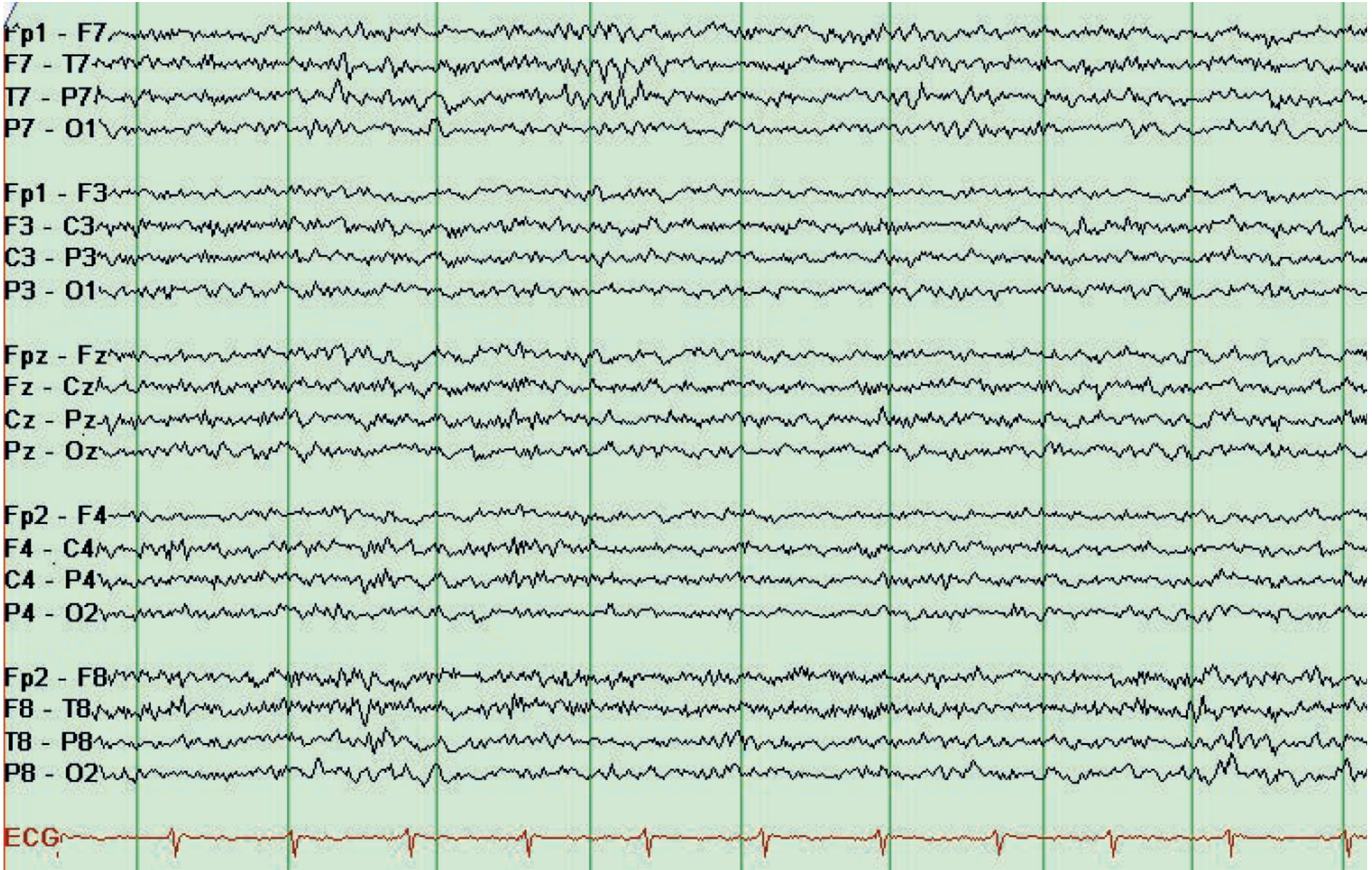
Female, Occipital, Low amplitude, Drowsy (FOLD)



Wicket Spikes

- **Morphology:** arciform appearance occurs in brief trains
- **Frequency:** 6-11 Hz
- **Location:** temporal
- **State:** drowsiness, light sleep
- Found in adolescents and adults
- No after-going slow wave or disruption of background

Wicket Spikes



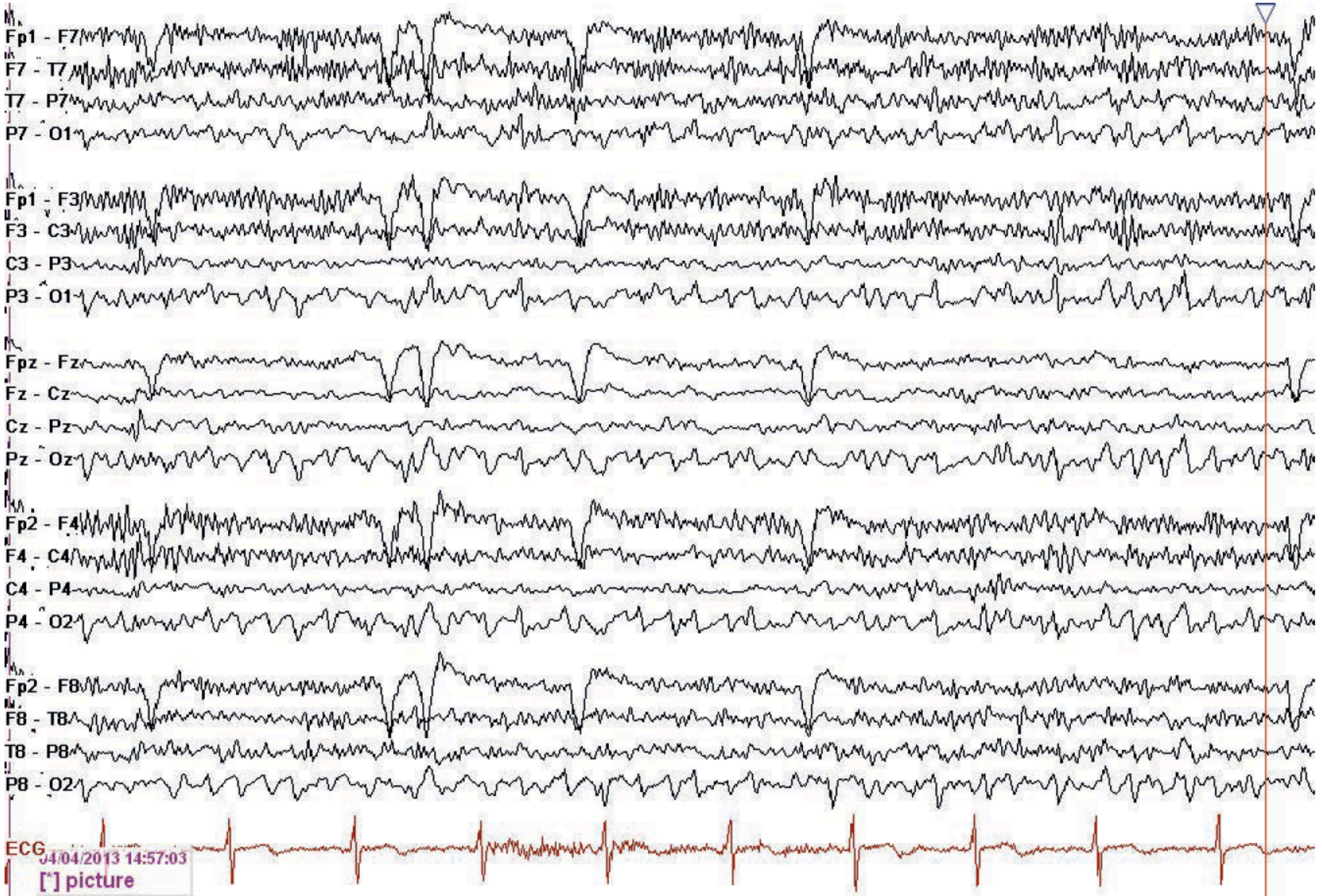
Normal Variants Patterns

1. Rhythmic patterns
2. Epileptiform patterns
3. Lambda and lambdoids
   - Lambda
   - Slow lambda of youth (Posterior slow waves of youth)
   - Positive occipital sharp transients of sleep (POSTS)
   - Slow lambdoids of youth (cone-shaped or O-waves)
4. Age related variants

Lambda

- **Morphology:** ‘λ’ biphasic waveform
- **Location:** occipital
- **State:** wakeful
- Appears when the patient scan a complex pattern design
- Block by eye closing
- Found in children > adults

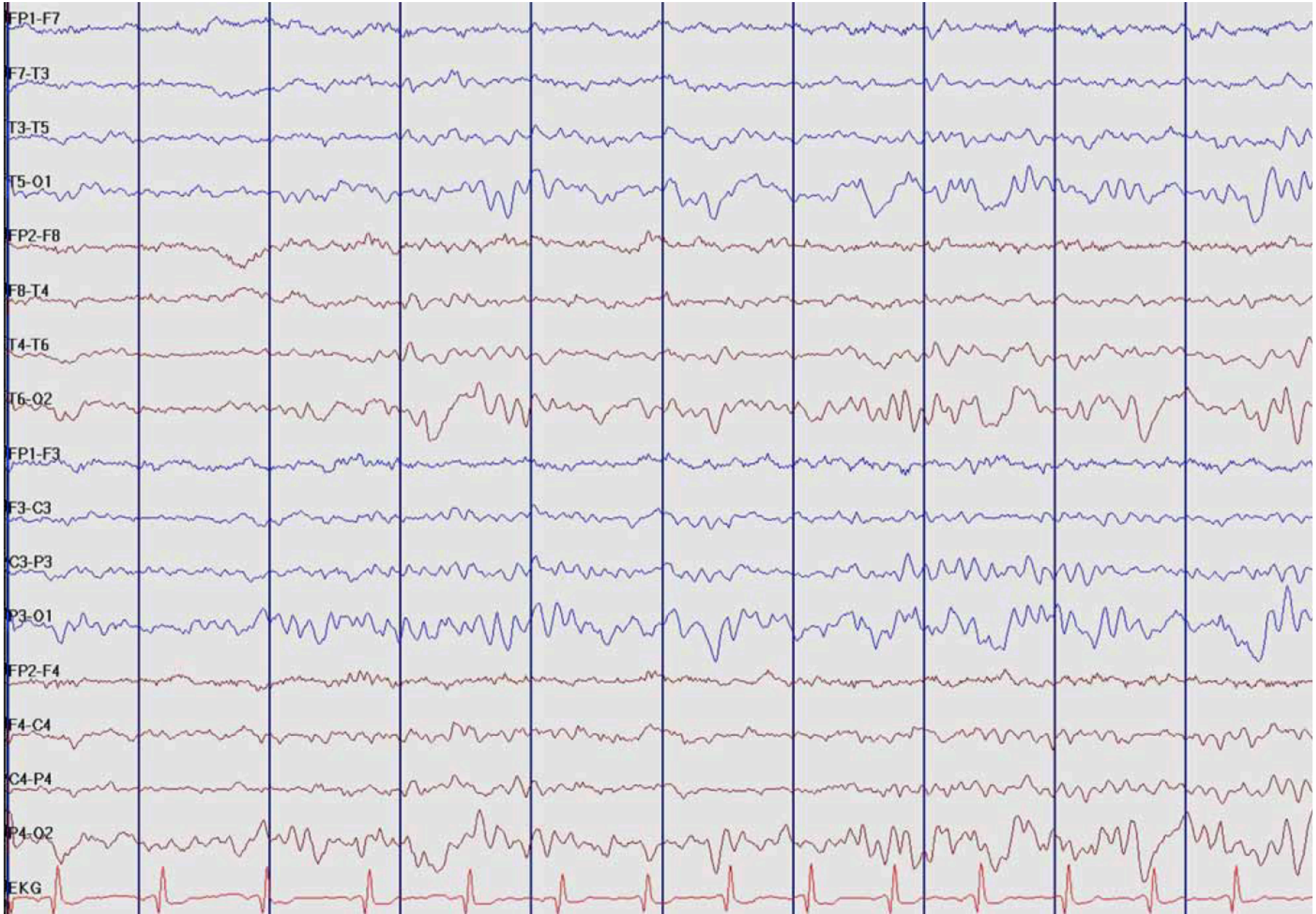
Lambda


Fp1 - F7
F7 - T7
T7 - P7
P7 - O1
Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fpz - Fz
Fz - Cz
Cz - Pz
Pz - Oz
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp2 - F8
F8 - T8
T8 - P8
P8 - O2
ECG
04/04/2013 14:57:03
[*] picture

Posterior Slow Waves of Youth

- **Morphology:** delta waveform superimposed with “alpha” on top
- **Location:** occipital
- **State:** wakeful
- Associated with eye closing
- Found in children 8-14 years of age

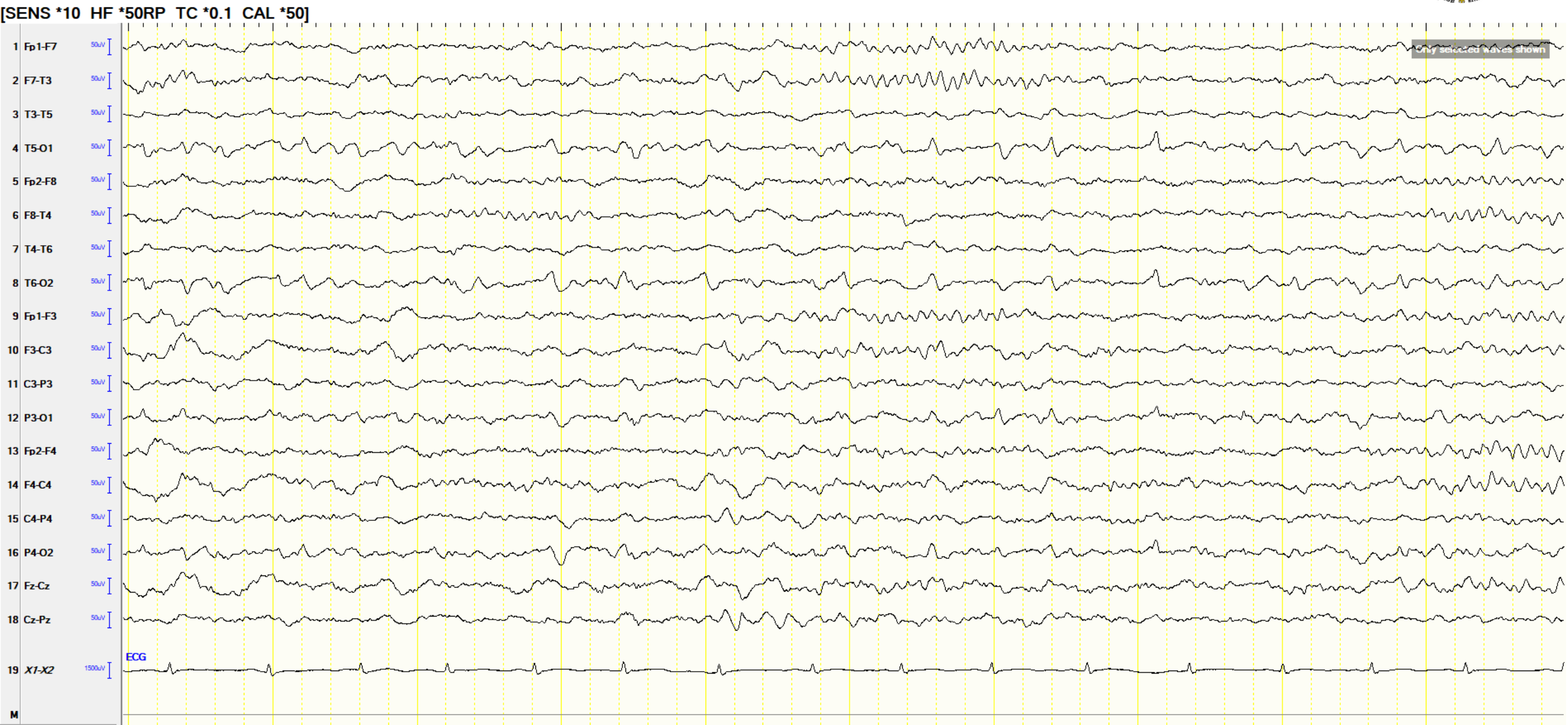
Posterior Slow Waves of Youth



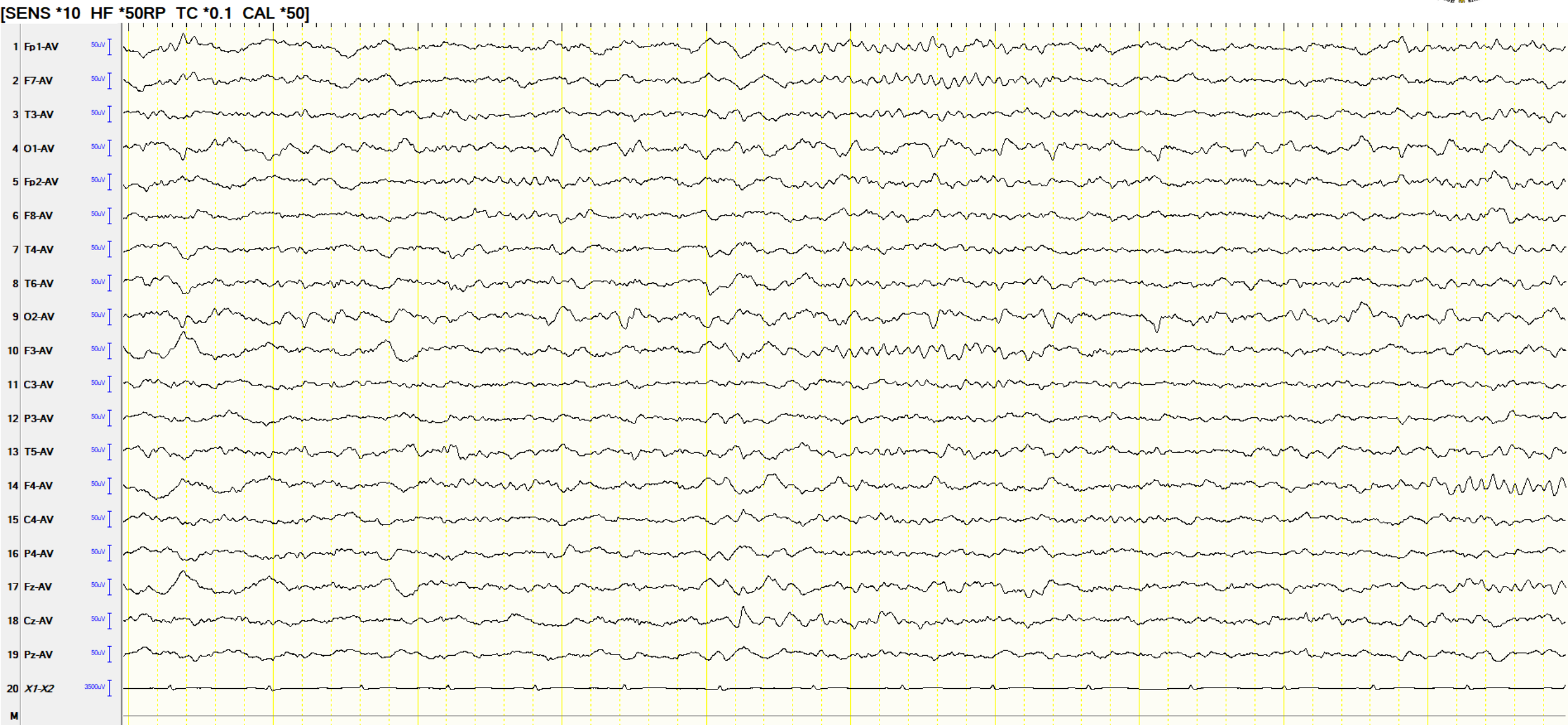
Positive Occipital Sharp Transients of Sleep (POSTS)

- **Morphology:** checkmark-like shape ✓, monophasic
- **Location:** occipital
- **State:** drowsy, sleep
- Surface positivity in occipital areas
- Occur in trains 4-5 Hz
- Found in children & adults

POSTS (Bipolar Montage)



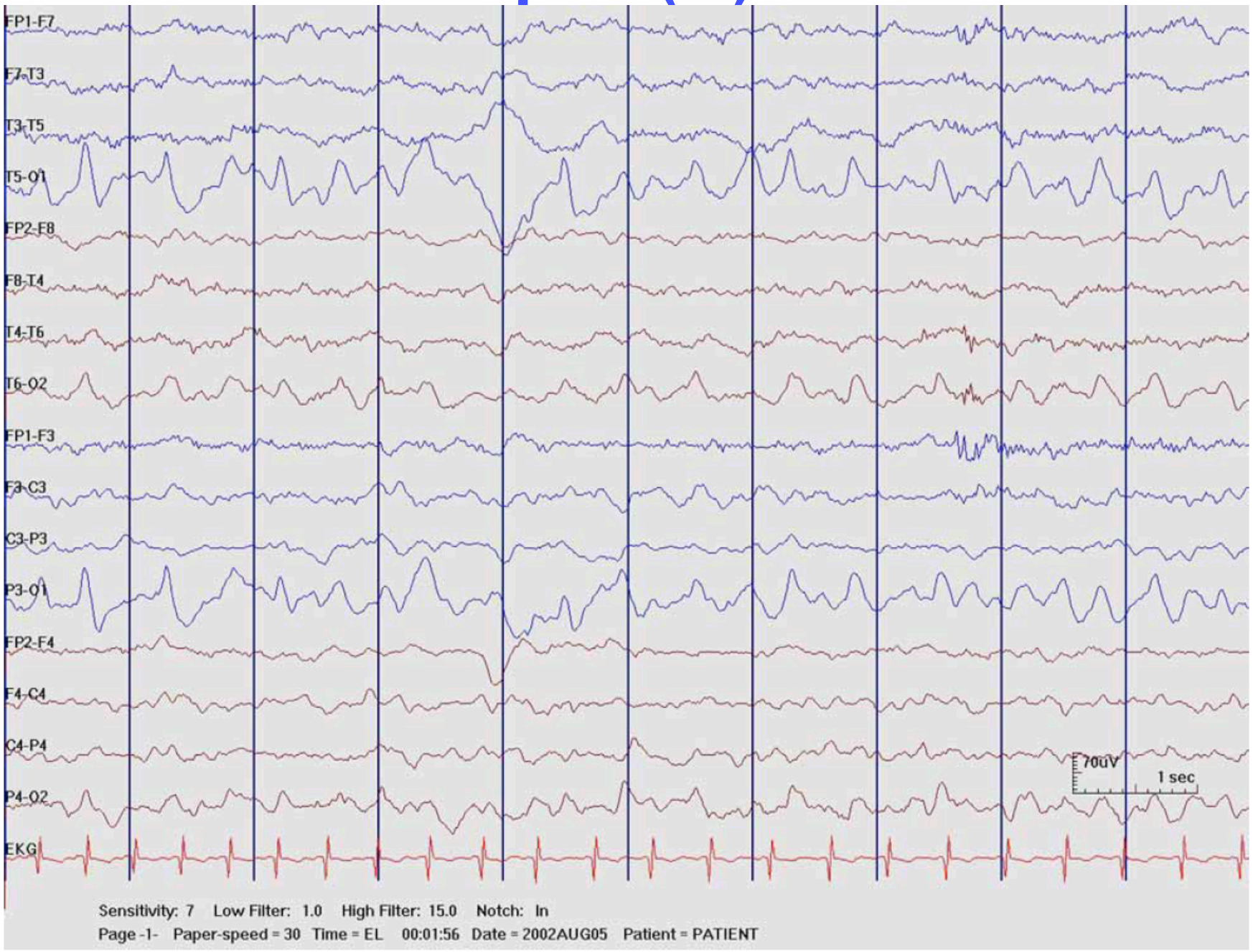
POSTS (Average Montage)



Slow Lambdoids of Youth (O-waves)

- **Morphology:** Cone or O shaped, high voltage, delta activity
- **Location:** occipital
- **State:** sleep
- Found in younger children up to 5 years of age

Cone Shaped (O) Waves



Normal Variants Patterns

1. Rhythmic patterns
2. Epileptiform patterns
3. Lambda and lambdoids
4. Age related variants
   - Hyperventilation-induced slowing
   - Hypnagogic and hypnopompic hypersynchrony

Hyperventilation Induced Slowing

- **Morphology:** rhythmic, high voltage, theta to delta activity
- **Location:** Age dependent- Prominent posteriorly in children, anteriorly in young adults
- **State:** during hyperventilation
- Return to baseline within 2 minutes
- Focal slowing during hyperventialtion is pathological

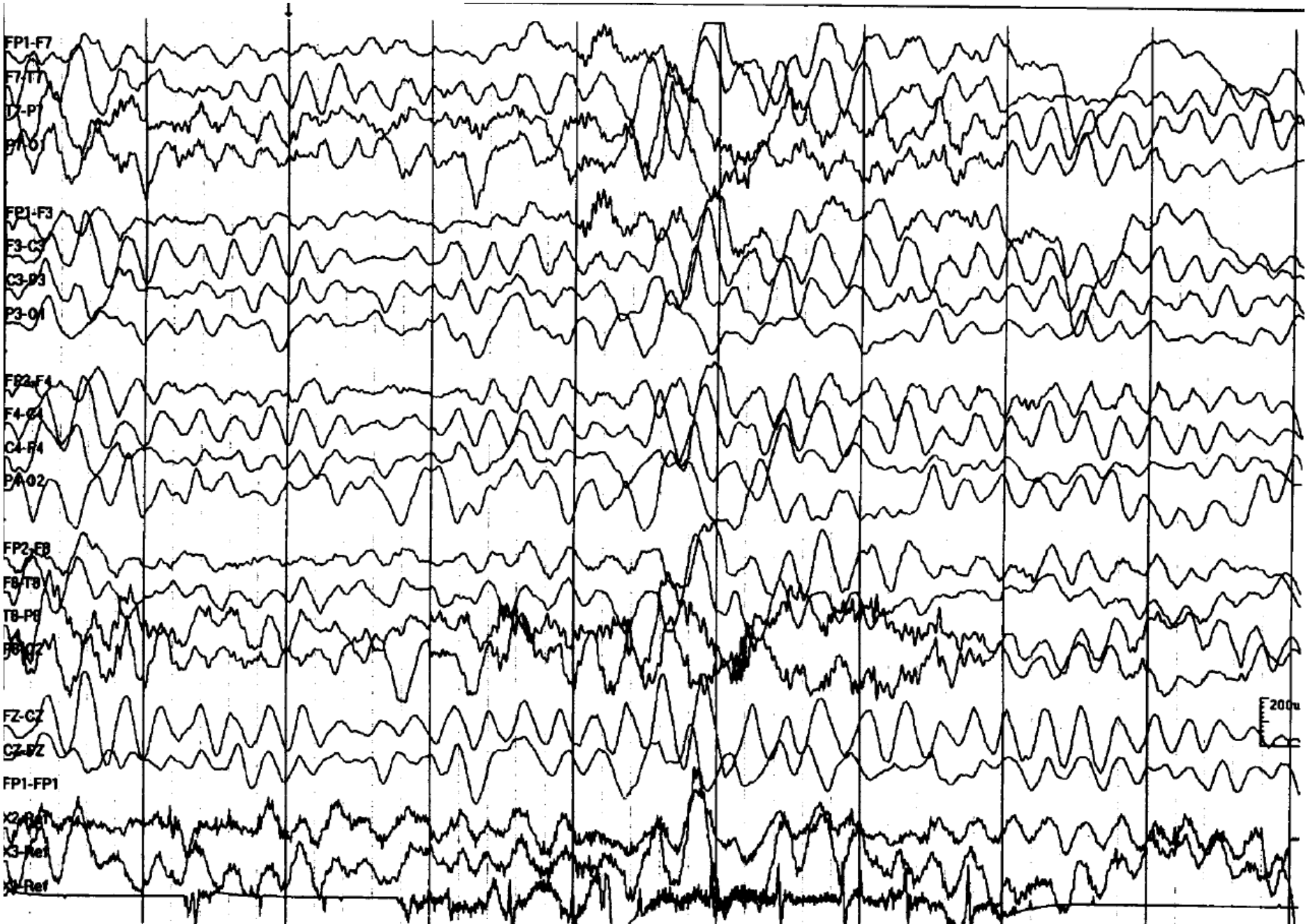
Hyperventilation Induced Slowing- 5 yo

Hyperventilation Induced Slowing- Adult

Hypnagogic/ Hypnopompic Hypersynchrony

- **Morphology:** high voltage, delta activity, spiky components
- **Location:** fronto-centro-parietal
- **State:** drowsiness
- Found in 2-4 years of age

Hypnagogic/ Hypnopompic Hypersynchrony



Conclusion

- It is essential to avoid misinterpretation of EEG
- Single electrode, nonreasonable field, or positive phase reversal indicate artifactual in nature
- Understanding the criteria to define normal variation and benign variants is crucial

Thank You For Your Attention