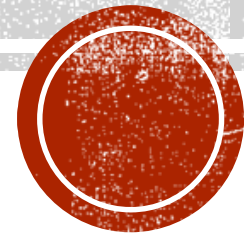


EPILEPTIFORM ABNORMALITIES

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JULY 27, 2016

EPILEPTIFORM PATTERNS

"distinctive waves or complexes, distinguished from background activity, and resembling those recorded in a proportion of human subjects suffering from epileptic disorders...."

Committee on terminology of The International Federation of Societies for Electroencephalography and Clinical Neurophysiology (IFSECN), 1974



EPILEPTIFORM PATTERNS

- **Interictal epileptiform pattern (IED)** : occur between clinical seizure
- **Ictal epileptiform pattern** : occur during clinical seizure



EPILEPTIFORM PATTERNS

- Focal epileptiform patterns
- Generalized epileptiform patterns
- Periodic/Pseudoperiodic epileptiform patterns



DEFINITION

- **Sharp waves**

- **Spikes**

- **Polyspikes**

- Sharply contoured waveforms that are distinct from the EEG background and usually have a negative polarity
- Sharp waves : duration shorter than 70 ms
- Spikes : duration between 70 ms and 200 ms
- Polyspikes: multiple spikes observed in rapid succession, typically at frequencies of 10 Hz or faster, may be followed by a slow wave



DEFINITION

- Spike-and-slow-wave complex
- Polyspike-and-slow wave complex
- varying frequency and amplitude: slow spike-and-waves (<3 Hz), 3-Hz spike-and-wave complexes and fast spike and wave (> 4Hz)
- Spike-and slow wave complex : the occurrence of a spike followed immediately by a slow wave (classically slow wave higher amplitude than spikes)
- Polyspike-and slow wave complex : same as SWC, but \geq spikes associated with one or more slow waves

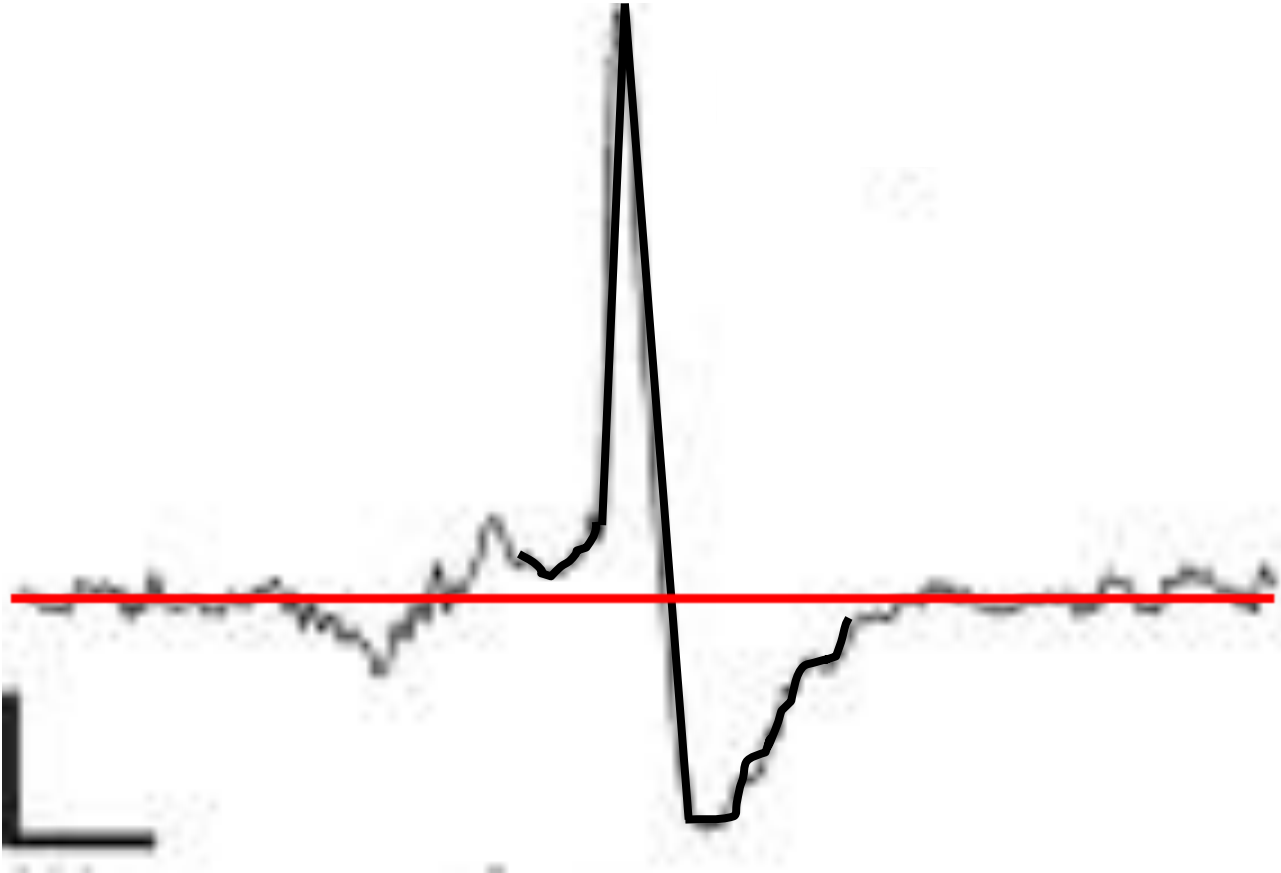


CRITERIA FOR INTERICTAL SPIKES AND SHARP WAVES

1. The discharge should be paroxysmal and clearly distinguished from background activity.
2. The discharge typically shows an abrupt change in polarity occurring over several milliseconds resulting in a sharp contour or spikiness.
3. The duration should be less than 200 ms. Spikes last between 20 and 70 ms, and sharp waves last between 70 and 200 ms. The distinction is morphologic in nature, and there is no clinical reason to distinguish between them.
4. The discharge must have a physiologic field, with the discharge recorded from more than one electrode and a voltage gradient should be present.
5. Spikes or sharp wave are typically negative in polarity.
6. Most spikes are followed by an aftergoing slow wave.



SHARP WAVES MORPHOLOGY



- Usually asymmetry, initial half of wave (from baseline to peak) shorter duration
- May followed by a slow wave
- More than one phase (usually 2 or 3)
- Out standing from background and interrupts ongoing background
- Involved more than one electrode site



MORPHOLOGY OF IED

- Sharp waves
- Spikes
- Polyspikes
- Spike/polyspike-and-wave

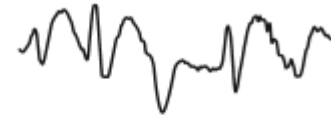
Spike



Slow wave



Spike and wave



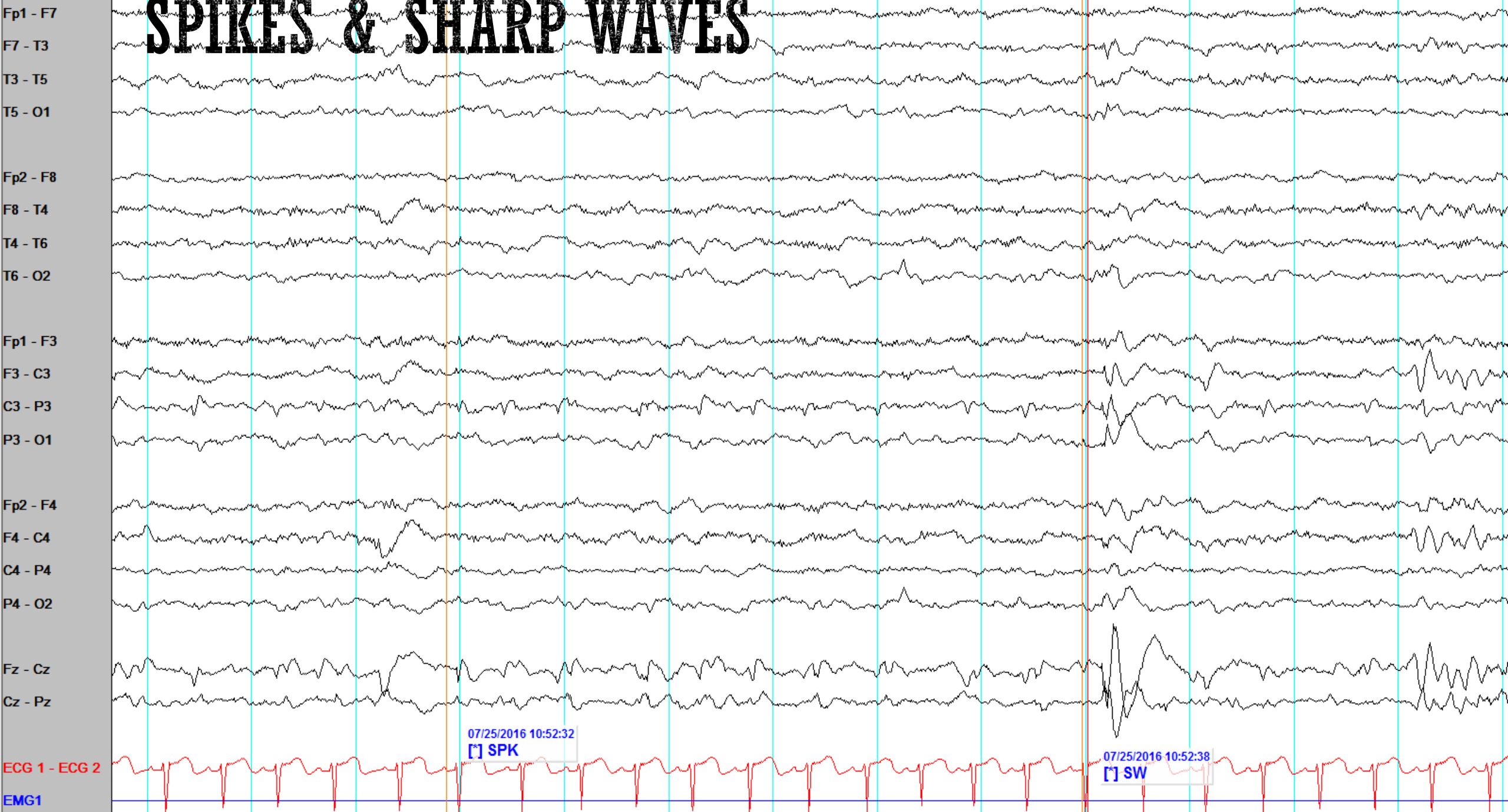
Multispike and wave



Epileptiform discharges.



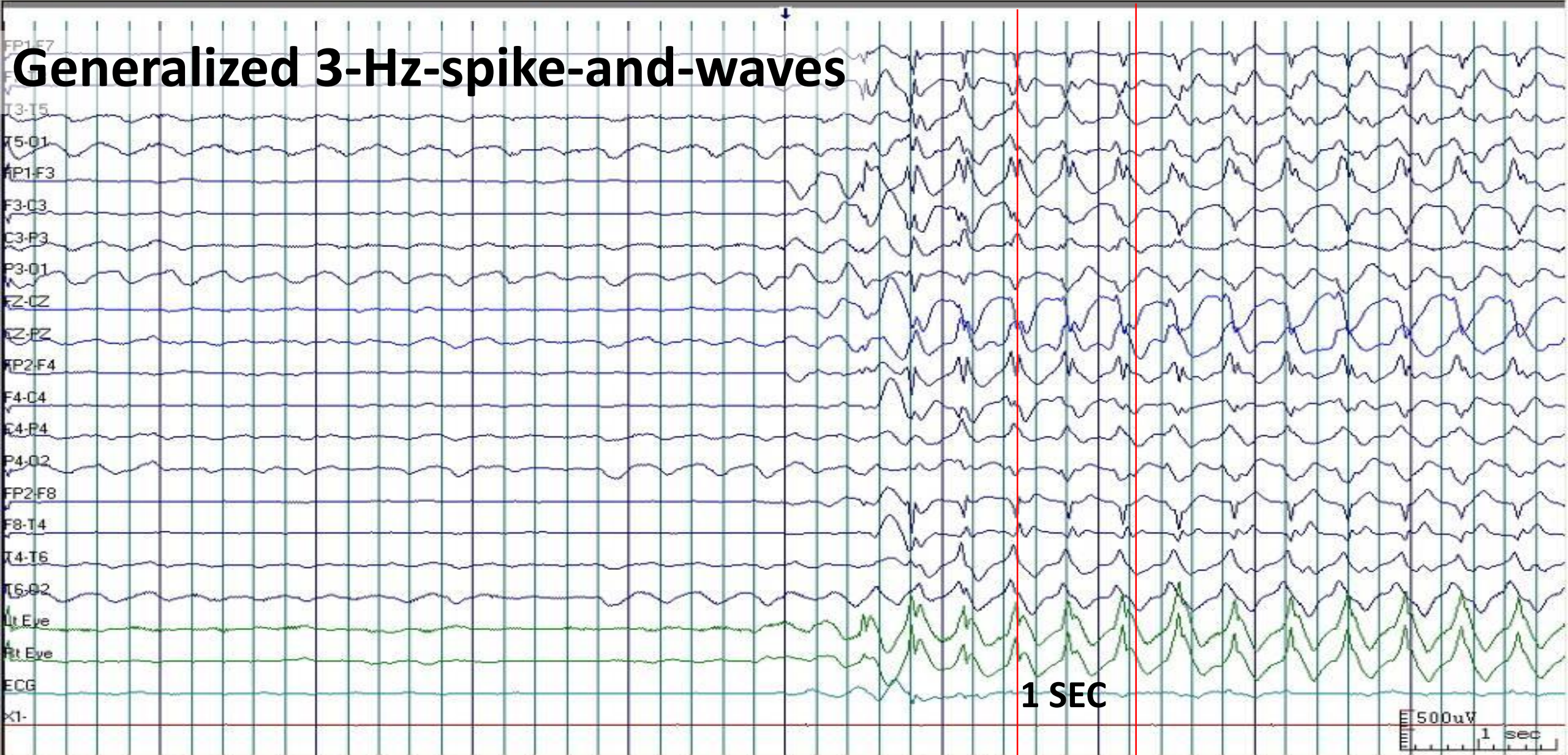
SPIKES & SHARP WAVES



POLYSPIKES



Generalized 3-Hz-spike-and-waves



FACTORS WHICH MODIFY SPIKE FREQUENCY

- Sleep
- Photic stimulation
- Hyperventilation
- Temporal relation to a seizure
- Age of patient
- Effect of anticonvulsant withdrawal



CAUTIONS

- 2.2-3.5% of non-epileptic patients had IEDs, only 5-14.1% eventually developed seizures/epilepsy
- Presence of IEDs is not diagnostic of epilepsy

Zivin and Ajmone-Marsan, 1980
Cavazutti et al, 1980

- The frequency of IEDs is not predict severity of epilepsy
e.g. BECTS
- Relationship between spikes and ictal activity is not know



FOCAL EPILEPTIFORM ACTIVITY

- Consists of spikes or sharp waves that appear at one or few neighboring electrodes
- Usually intermittent but may repeat briefly with little or no variation of shape



FOCAL EPILEPTIFORM ACTIVITY BY LOCATION

A. Locate usually outside of temporal and fronto-temporal areas in

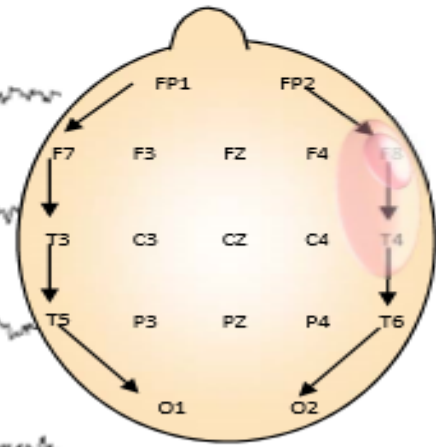
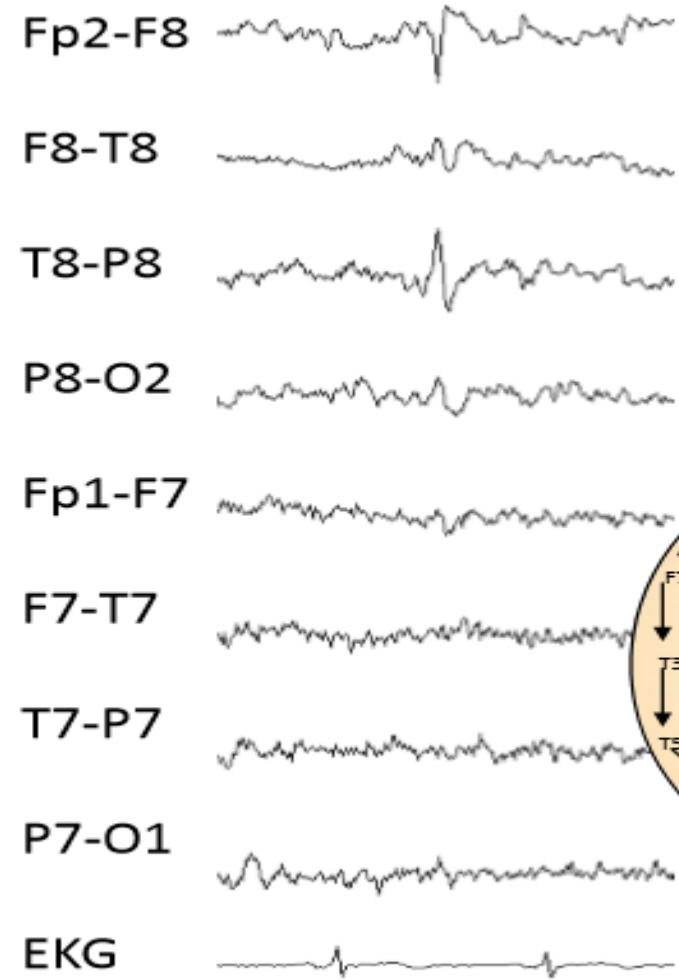
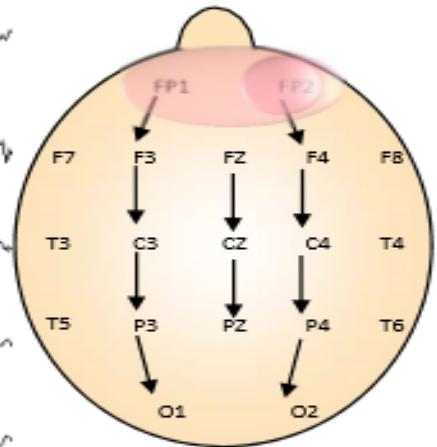
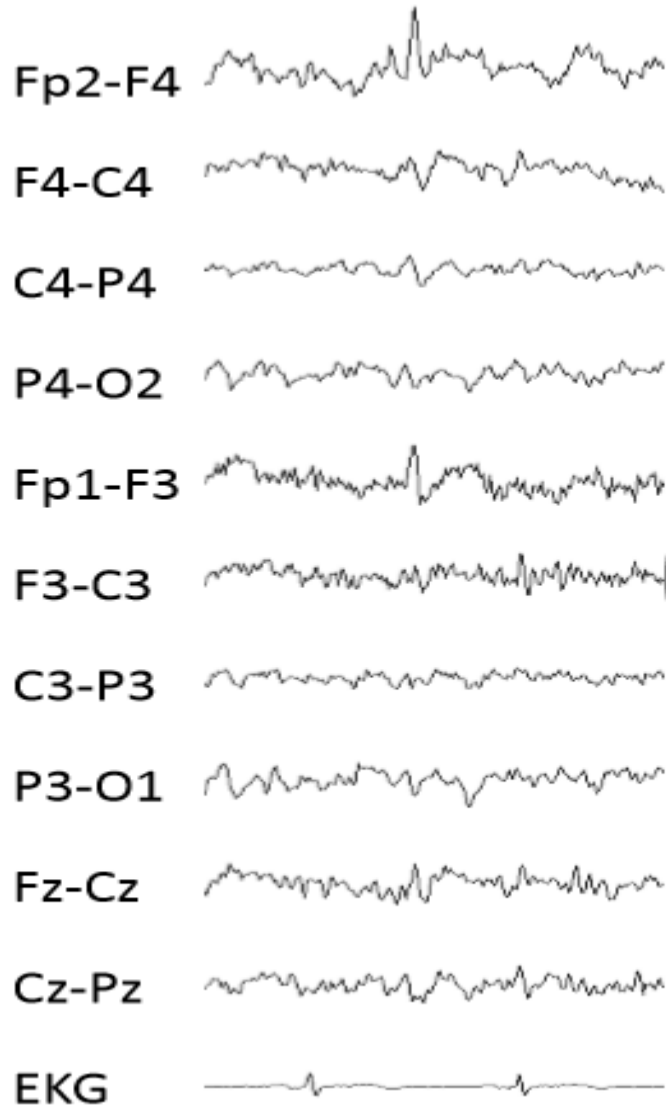
- 1. Motor cortex**
- 2. Sensory cortex**
- 3. Insula, Sylvian fissure, mesial frontal cortex**
- 4. Cortex of more than one area**

B. Locate usually in temporal or fronto-temporal areas

C. Followed by generalized epileptiform activity as in A and B, occasionally followed by generalized epileptiform activity



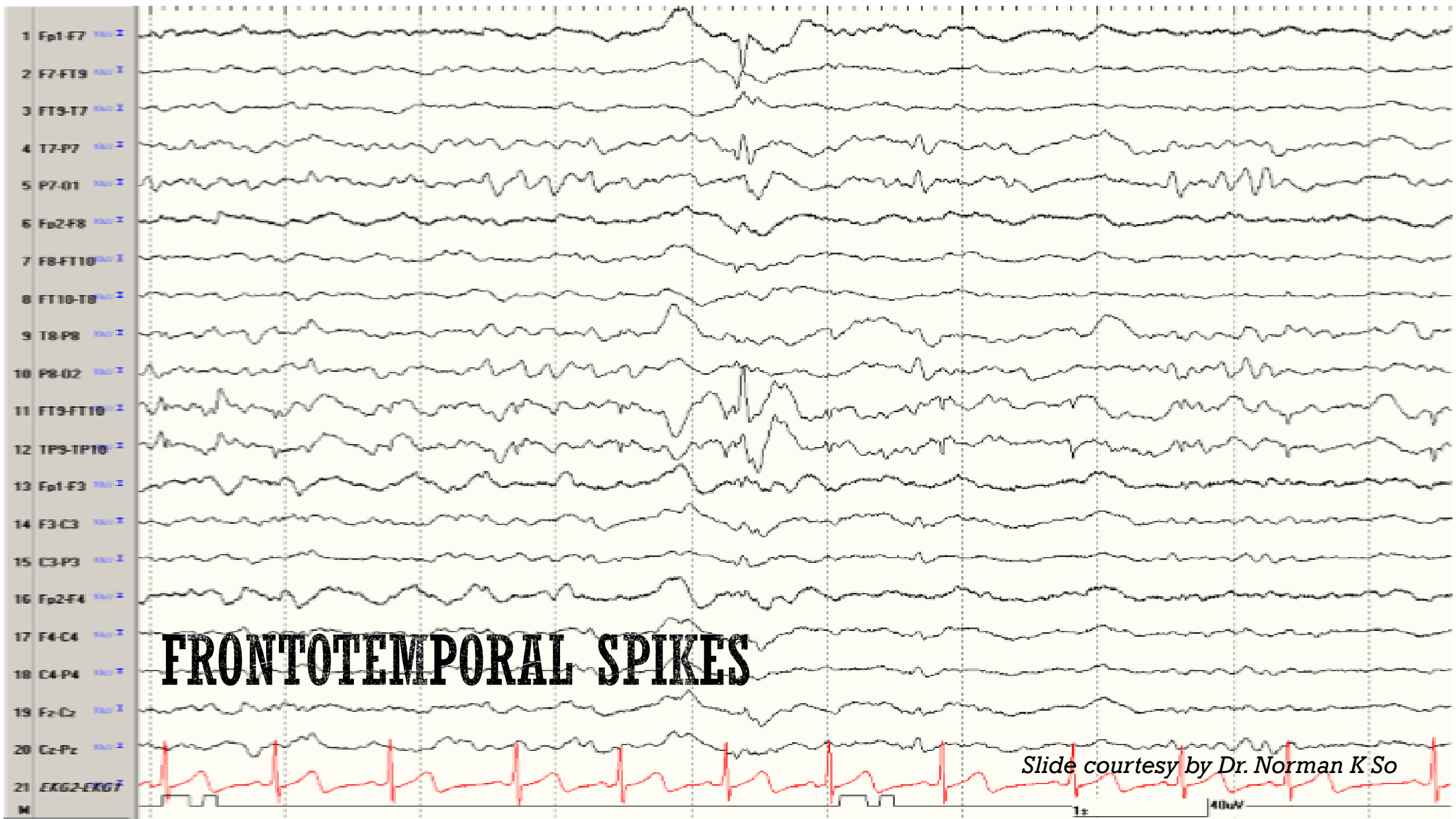
FRONTOPOLAR AND FRONTAL SPIKES



100 μ V
1s

Slide courtesy by Dr. Norman K So



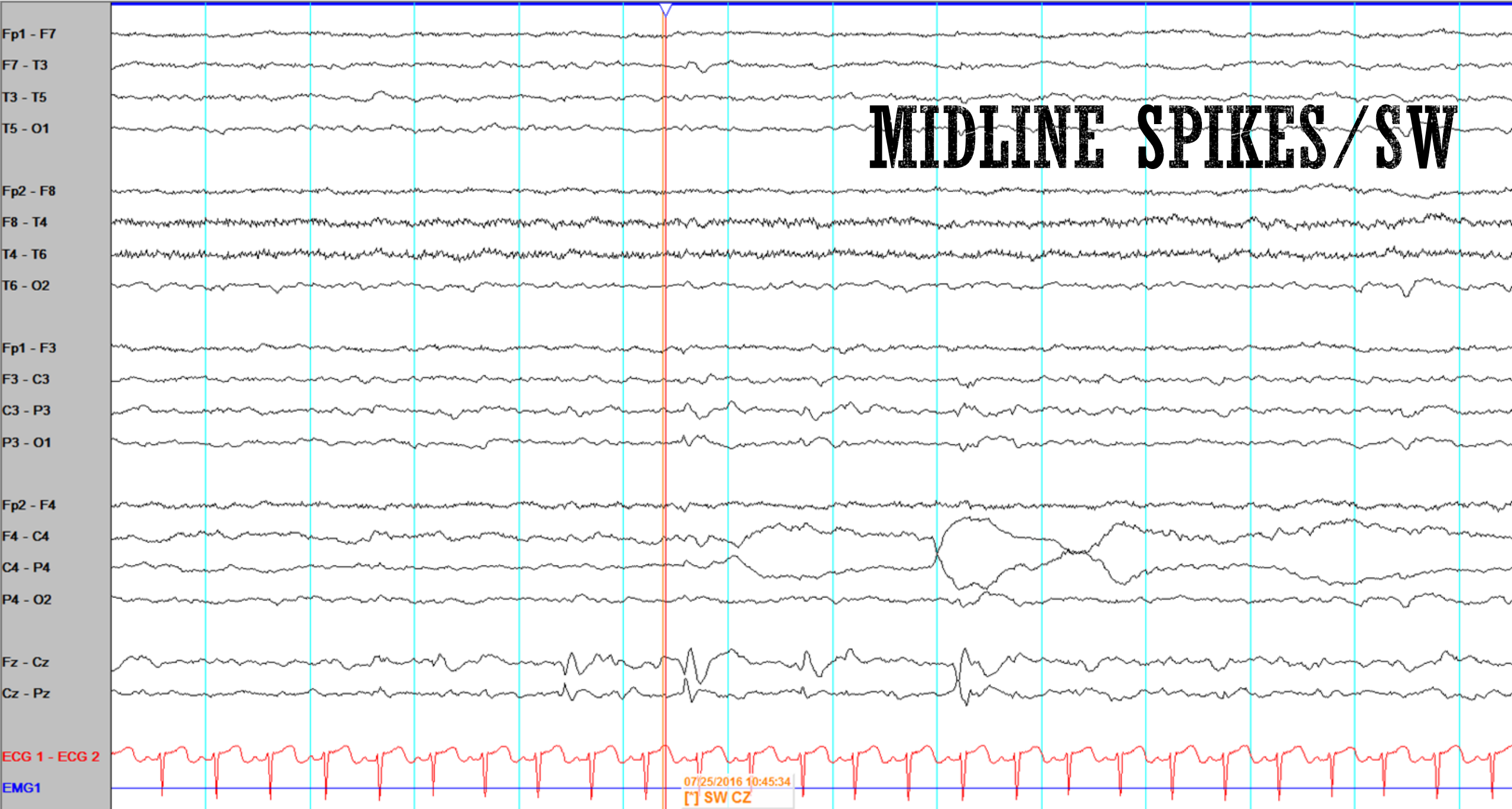


FRONTOTEMPORAL SPIKES

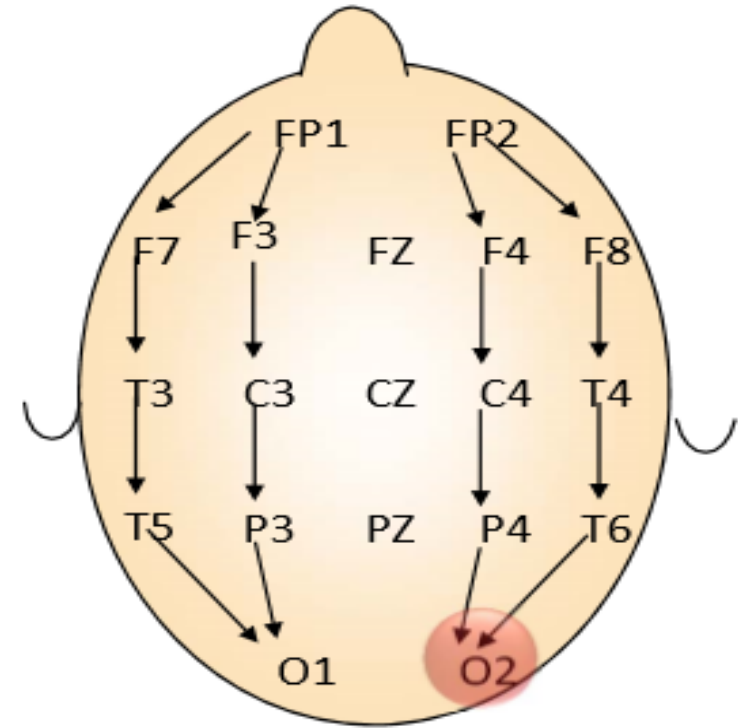
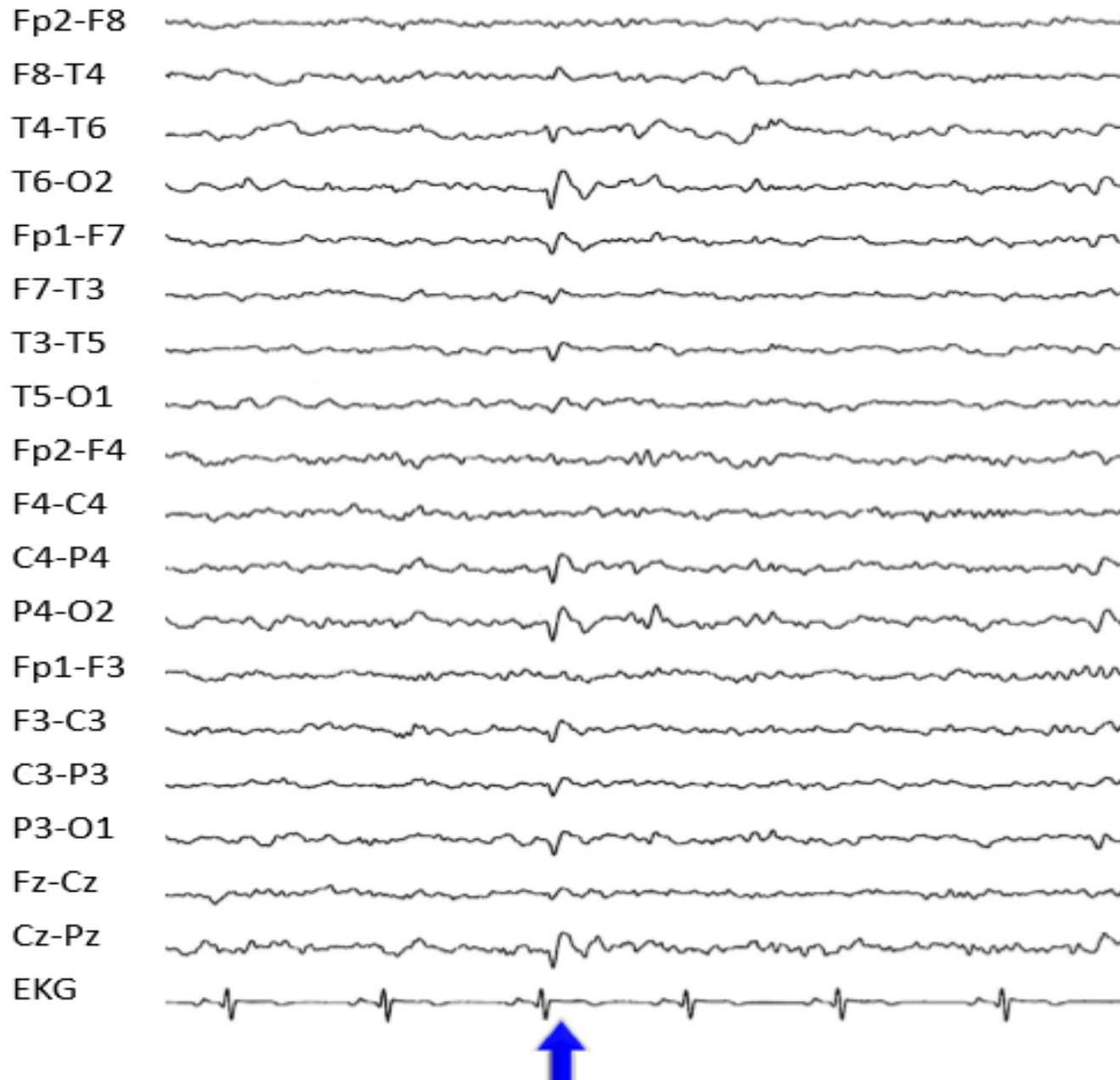
Slide courtesy by Dr. Norman K So

1s 40uV

MIDLINE SPIKES / SW



OCCIPITAL SPIKES



1s 50 μ V

Slide courtesy by Dr. Norman K So



MULTIFOCAL SHARP WAVES

- In childhood multifocal or symptomatic generalized epilepsy
- In diseases with multifocal abnormalities: e.g.:
tuberous sclerosis, cortical malformations,
Rasmussen syndrome
- Around large lesions



MULTIFOCAL SPIKES

Fp1 - F7

F7 - FT9

FT9 - T3

T3 - T5

T5 - O1

Fp2 - F8

F8 - FT10

FT10 - T4

T4 - T6

T6 - O2

Fp1 - F3

F3 - C3

C3 - P3

P3 - O1

Fp2 - F4

F4 - C4

C4 - P4

P4 - O2

Fz - Cz

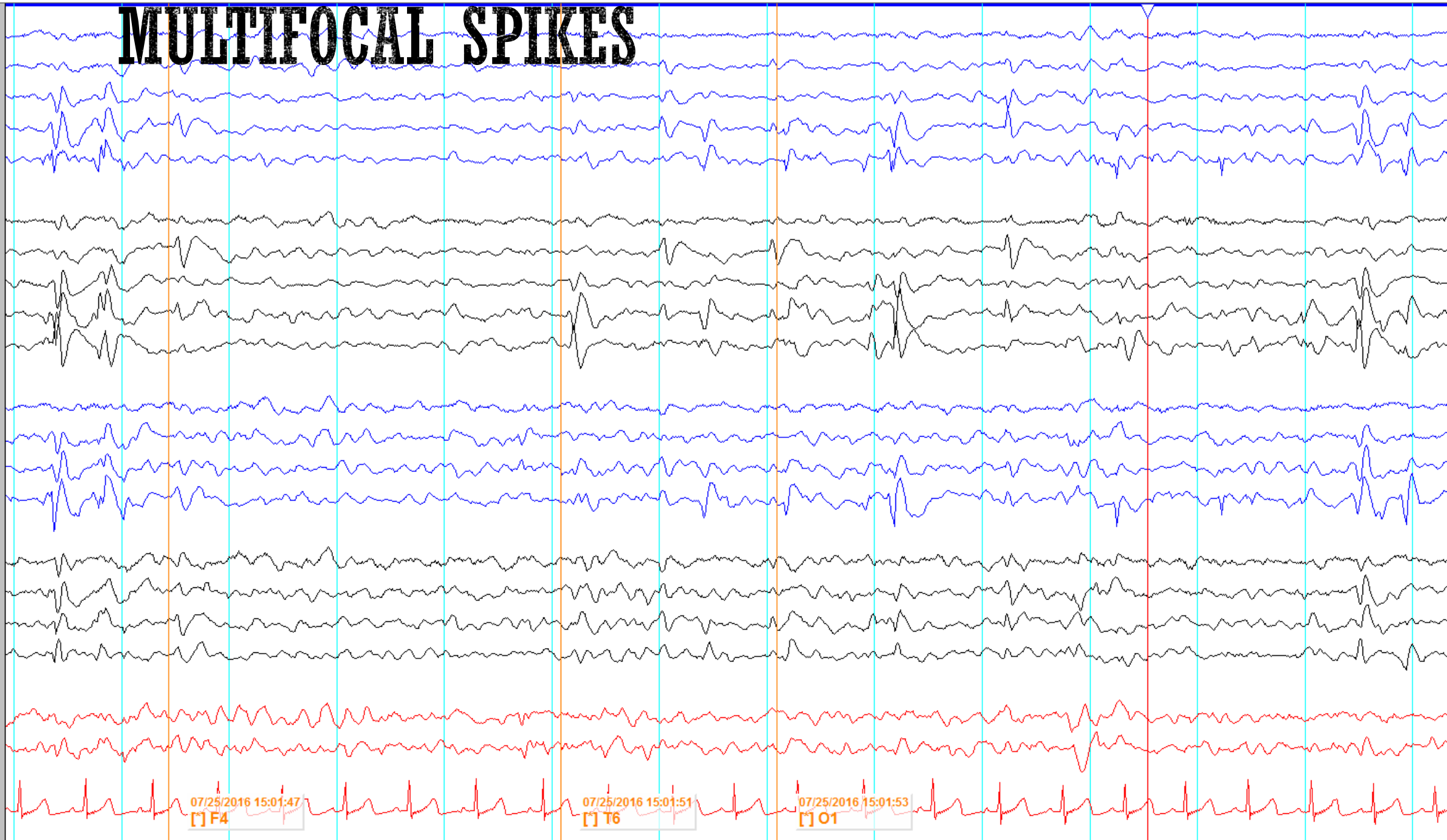
Cz - Pz

ECG 1 - ECG 2

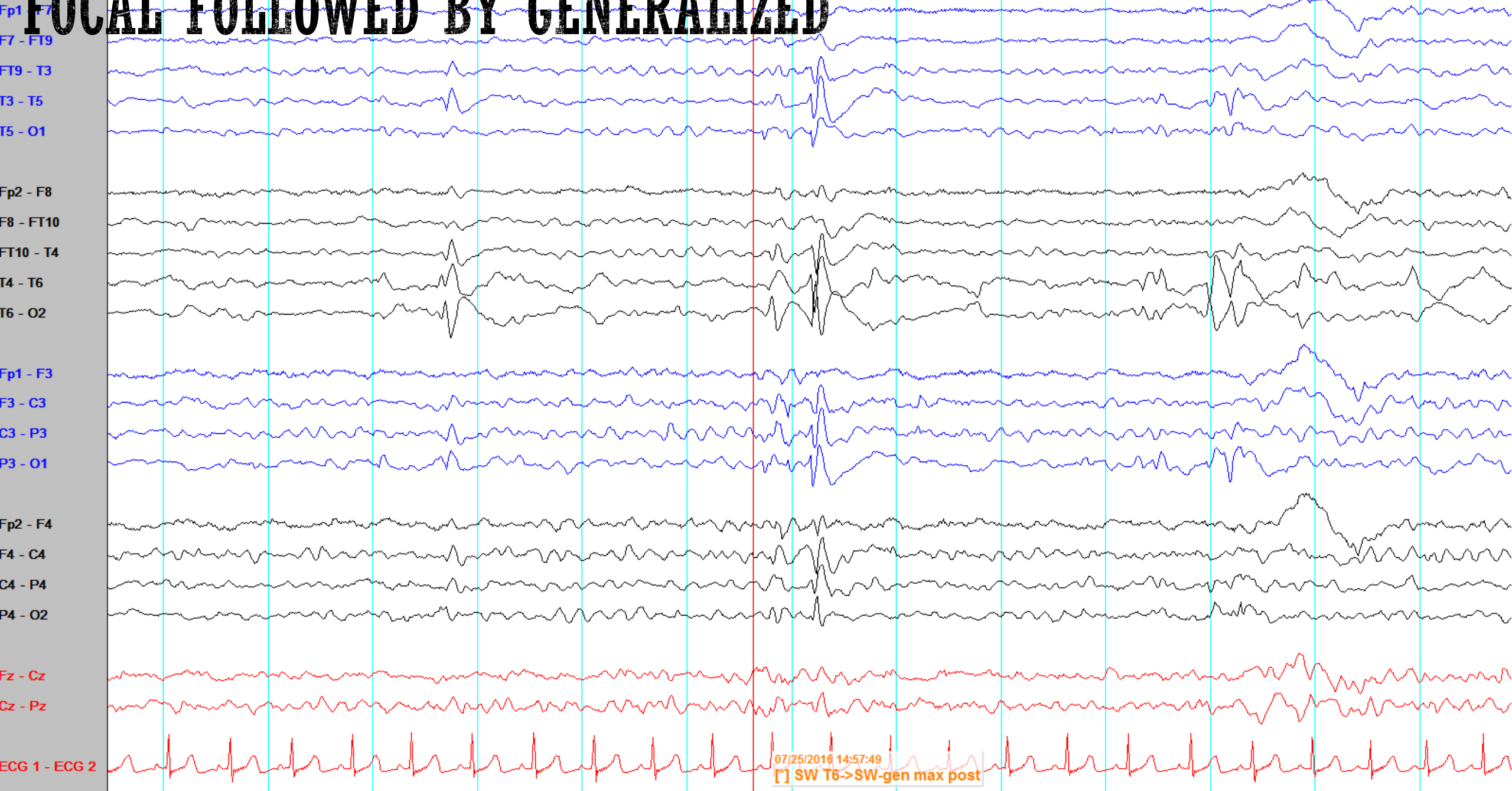
07/25/2016 15:01:47
[] F4

07/25/2016 15:01:51
[] T6

07/25/2016 15:01:53
[] O1



FOCAL FOLLOWED BY GENERALIZED



BENIGN EPILEPSY OF CHILDHOOD WITH CENTRO-TEMPORAL SPIKES (BECTS)

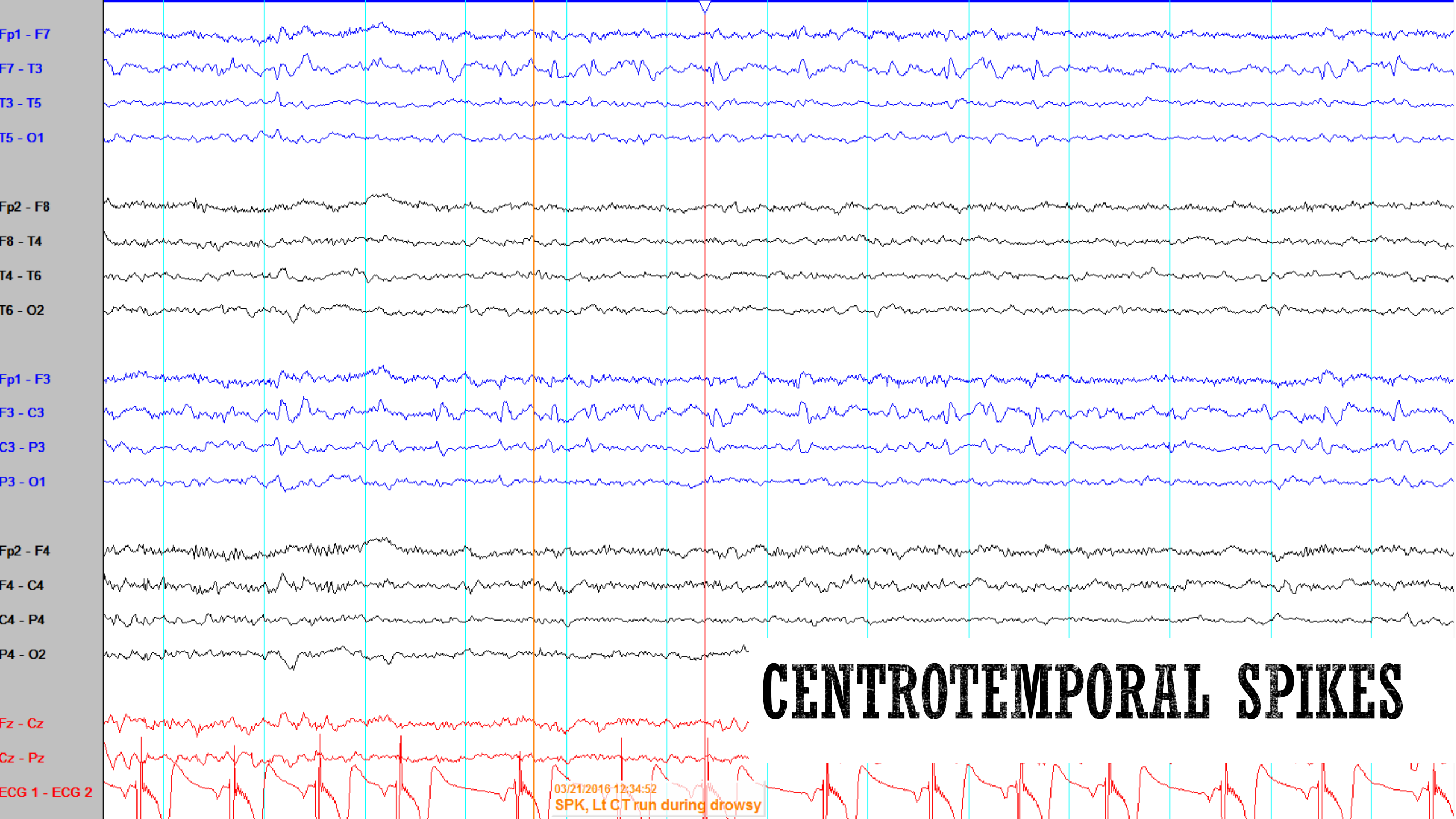
- High amplitude diphasic sharp wave with smaller aftergoing slow wave
- Central or Temporal maxima
- Often dipole with central or temporal negativity and frontal positivity
- Preserved background activity
- Marked activation in NREM sleep-ipsilateral, bilateral, multifocal
- Bursts of bilateral discharges in sleep





CENTROTEMPORAL SPIKES

97.0	97.0	97.0	96.9	96.5
113	113	113	112	113



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

ECG 1 - ECG 2

CENTROTEMPORAL SPIKES

03/21/2016 12:34:52
SPK, Lt CT run during drowsy

FOCAL EPILEPTIFORM ACTIVITY & CLINICAL CORRELATIONS

- Location and likelihood of seizure (Kalleway, 3526 children):
 - Temporal 90-95%
 - Frontal 70-80%
 - Parieto-occipital 40-50%
 - Central 30-40%

- Focal/ Partial epilepsy :
 - Motor and sensory area correlate with motor and sensory symptoms
 - Temporal or fronto-temporal areas correlate with psychic or special sensory symptoms



GENERALIZED EPILEPTIFORM ACTIVITY

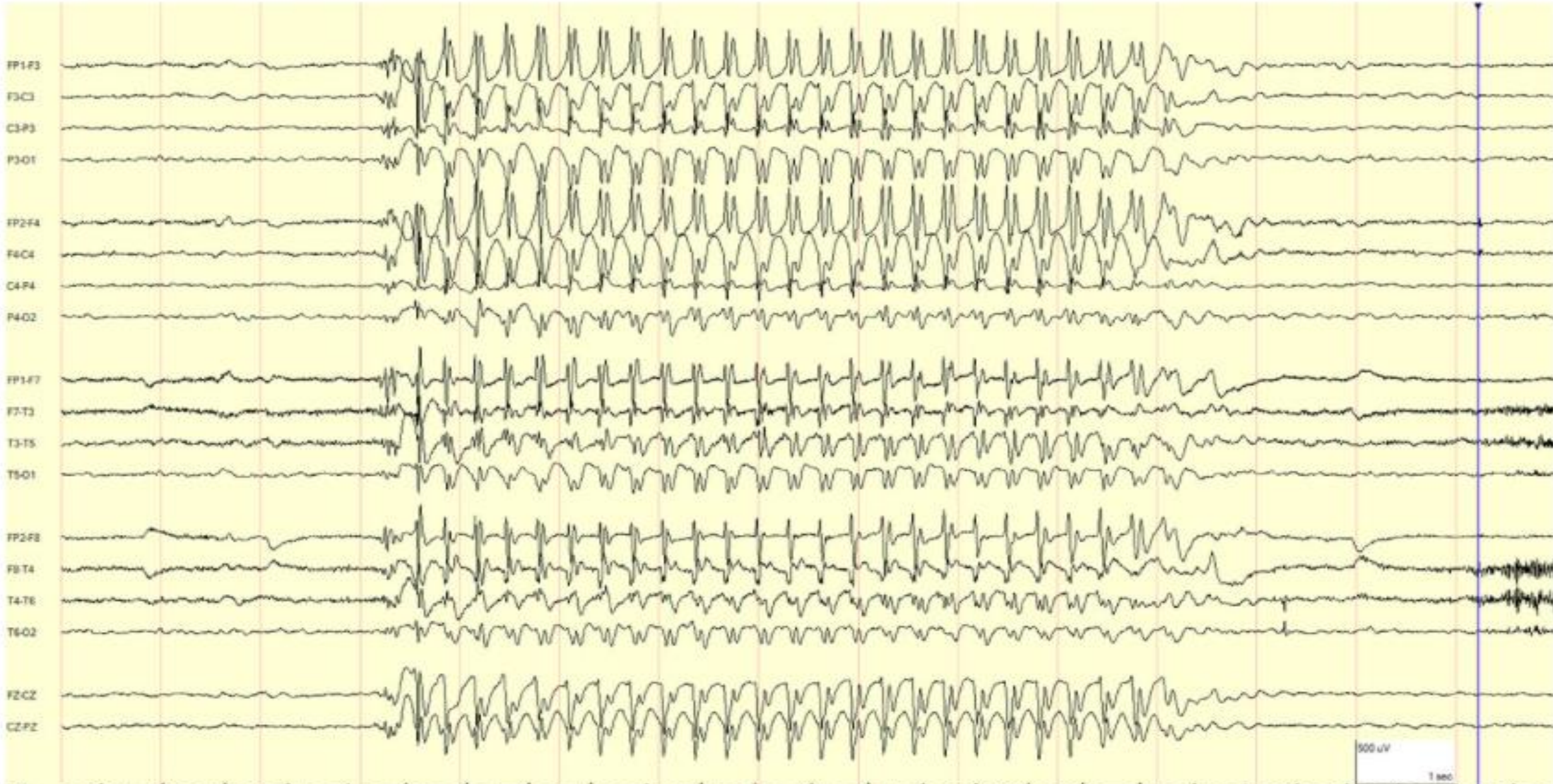
- Variable morphology: spikes, sharp waves, spike wave complexes, polyspikes
- Variable antero-posterior gradient of maximal involvement, usually maximal bifrontal
- Bilateral synchrony
- No consistent asymmetry—but variable shifting predominance not uncommon
- No consistent focal leading or independent component



3 HZ SPIKE-WAVE COMPLEX

- A spike or spikes of high amplitude followed by slow wave of similar or higher amplitude. Maximum frontal midline region
- May be faster (4 Hz) at the onset and then slow down to 2.5 Hz at the end
- Hyperventilation test can produced
- Clinical correlations: Absence seizure/epilepsy





3 HZ SPIKE-AND-WAVE

SLOW SPIKE WAVE COMPLEX(1-2.5 HZ)

- A sequence of spike and wave or sharp and slow waves at 1-2.5 Hz. Maximum frontal midline region
- Usually bilateral or generalized synchronous
- Symmetrical or not (lateralized or localized)
- Clinical correlations: atypical absence seizure, Lennox Gastaut syndrome



Fp1 - F7
F7 - FT9
FT9 - T3
T3 - T5
T5 - O1

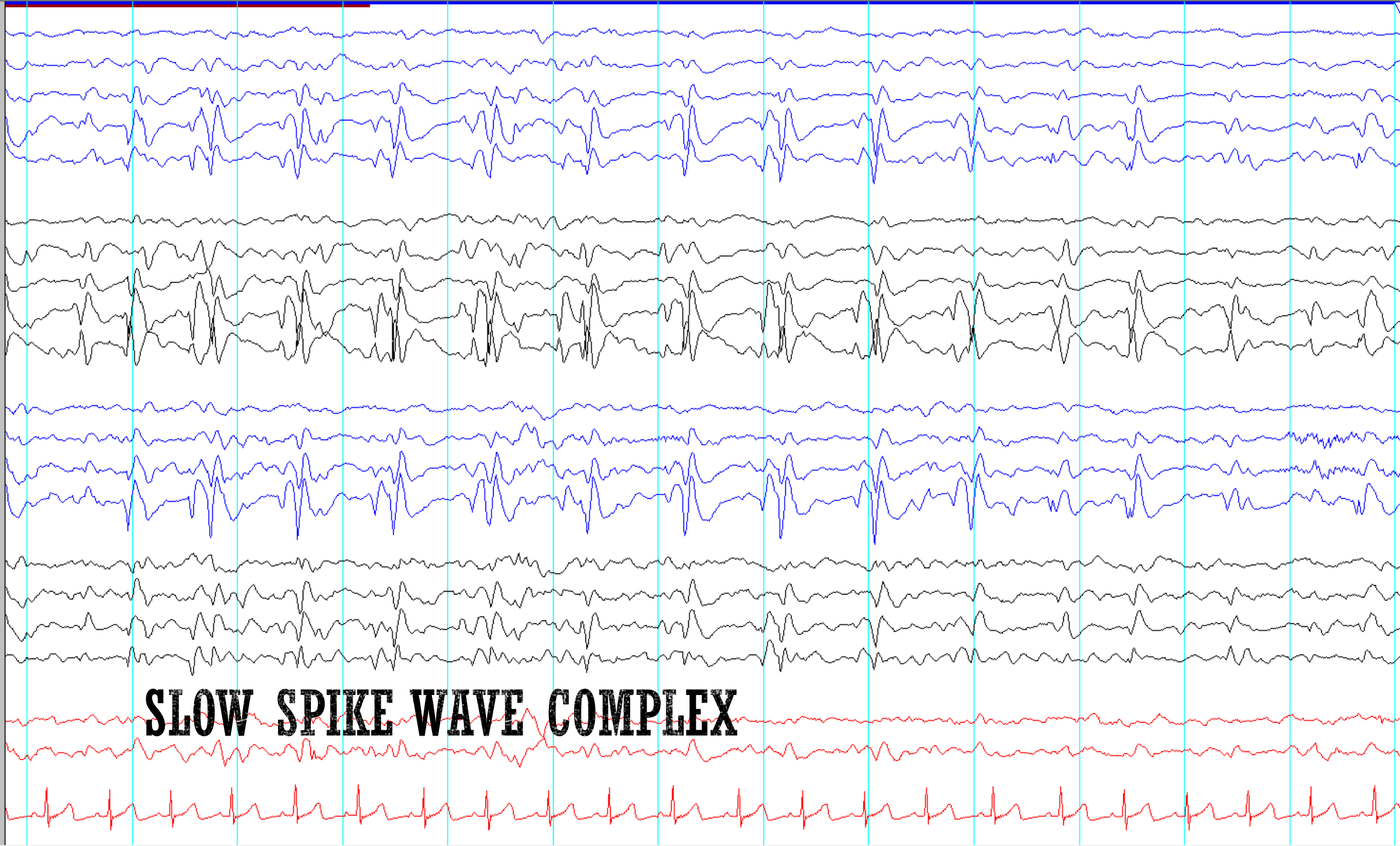
Fp2 - F8
F8 - FT10
FT10 - T4
T4 - T6
T6 - O2

Fp1 - F3
F3 - C3
C3 - P3
P3 - O1

Fp2 - F4
F4 - C4
C4 - P4
P4 - O2

Fz - Cz
Cz - Pz

ECG 1 - ECG 2



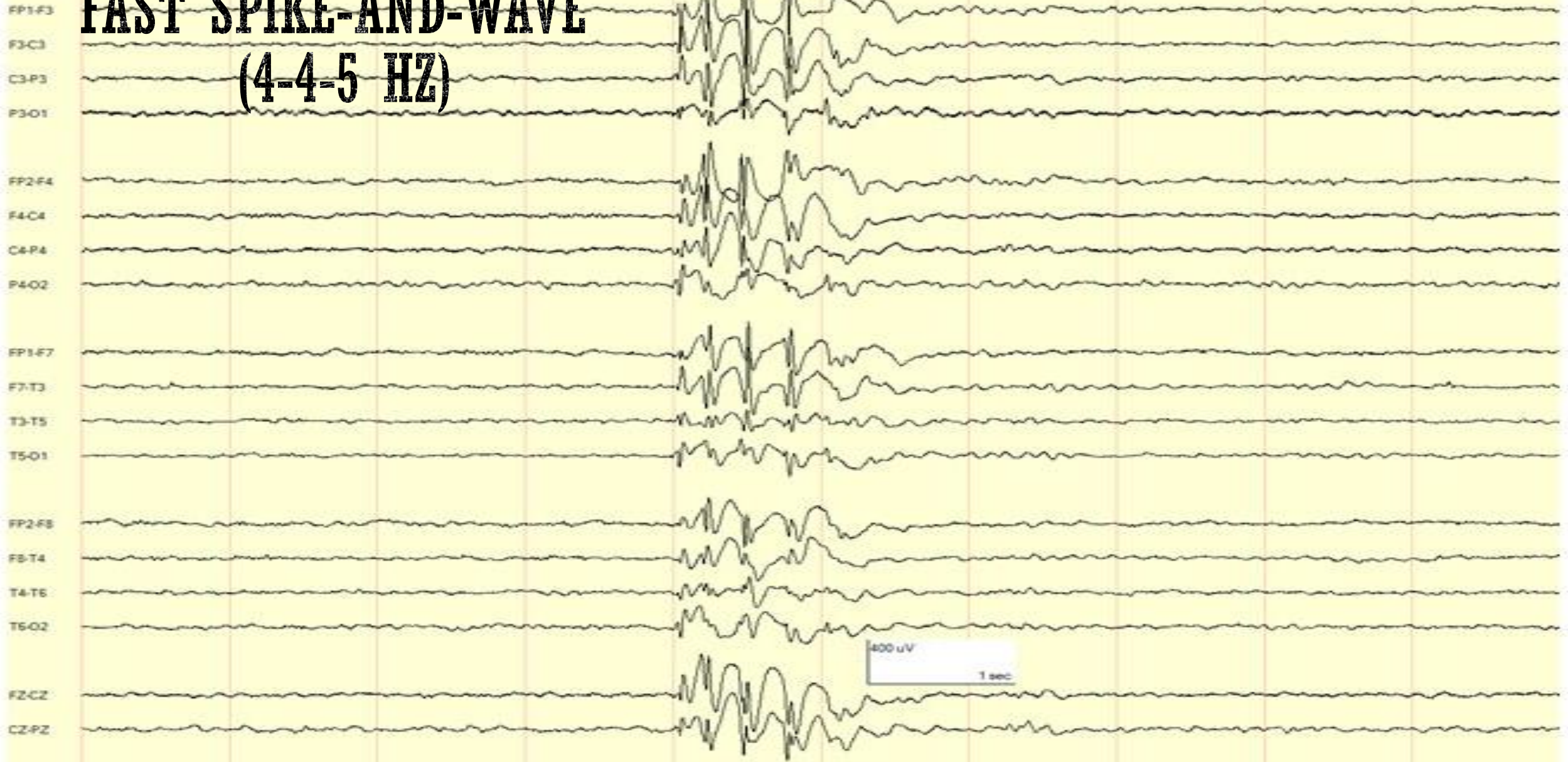
SLOW SPIKE WAVE COMPLEX

FAST SPIKE AND WAVE COMPLEX

- Irregular spike wave complexes, generalized, maximum bifrontal
- 3.5-5 Hz, brief 0.5-5 seconds
- Clinical association: JME, idiopathic grand mal epilepsy, myoclonic epilepsy (PME and others)

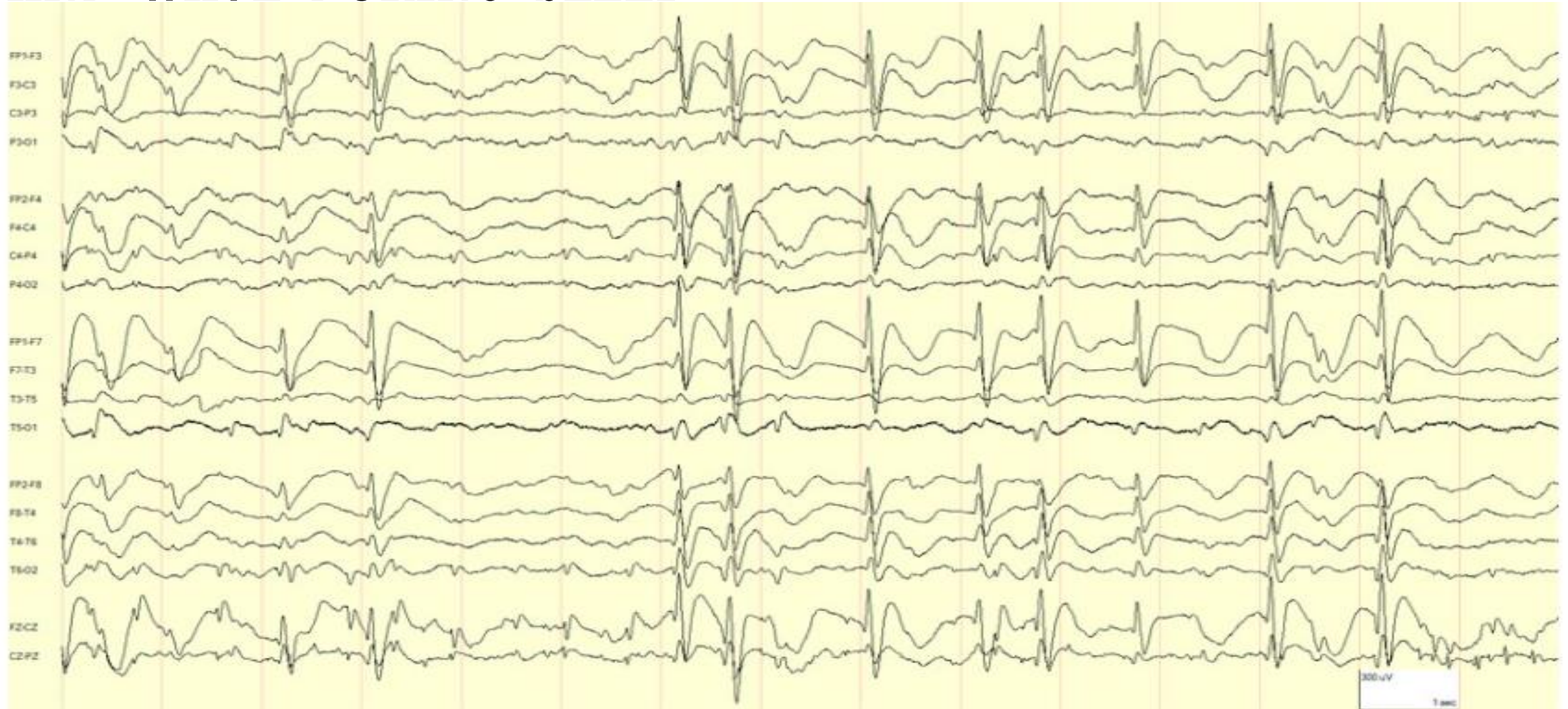


FAST SPIKE-AND-WAVE (4-4-5 HZ)



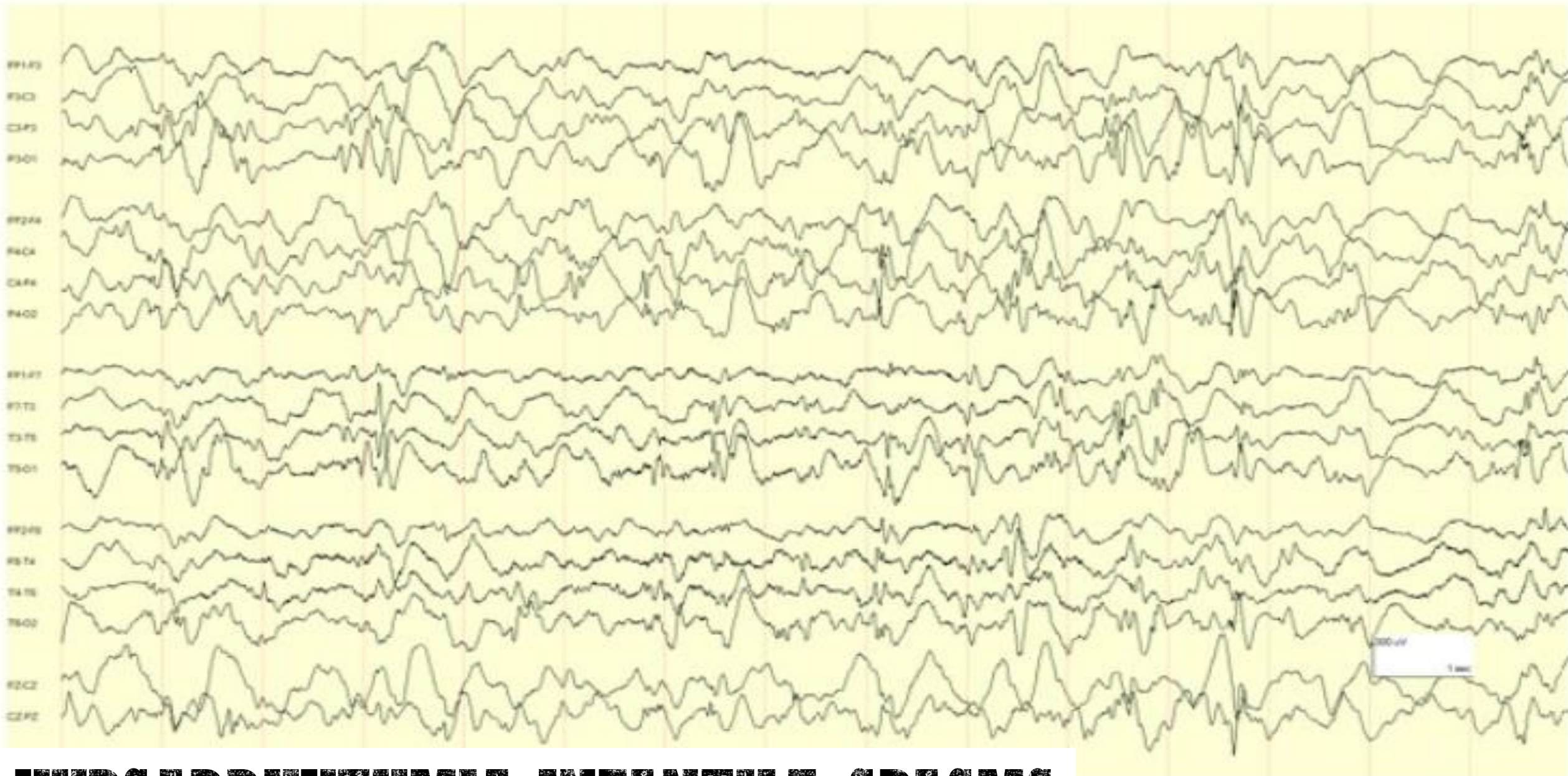
Example of 3-6Hz generalized spike-and-wave

EPILEPTIC ENCEPHALOPATHY WITH CONTINUOUS SPIKE-AND-WAVE DURING SLEEP



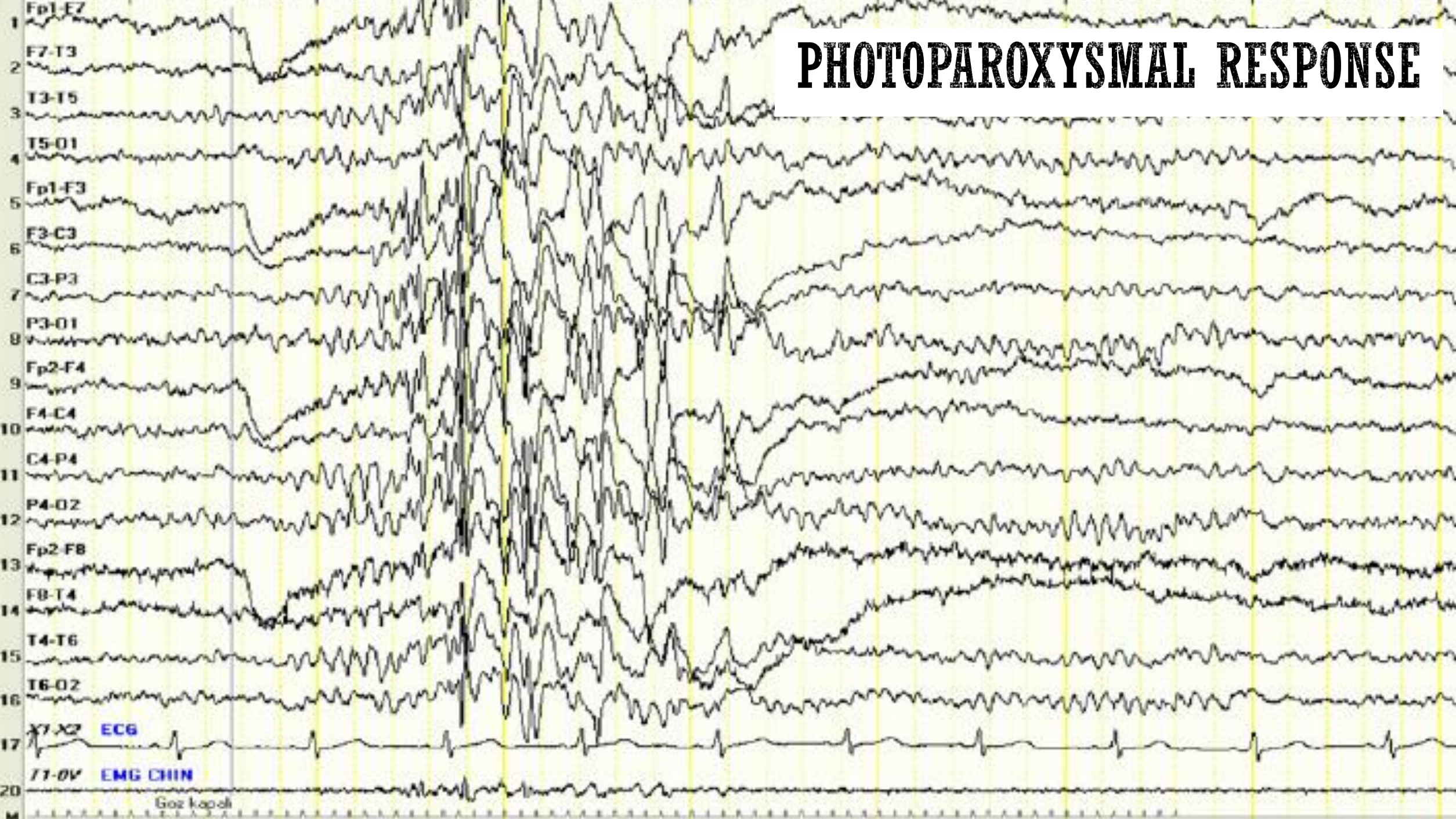
Example of continuous spike-and-wave during sleep.





HYPARRHYTHMIA-INFANTILE SPASMS

PHOTOPAROXYSMAL RESPONSE



INTERICTAL EPILEPTIFORM PATTERNS

Idiopathic Epilepsy

- Generalized
 - 3 Hz spike-and-wave
 - Polyspikes
 - Atypical spike-and-wave
- Partial/Focal
 - Benign focal epilepsy of childhood with centrotemporal spikes
 - Benign focal epilepsy of childhood with occipital spikes

Symptomatic Epilepsy

- Generalized
 - Hypsarrythmia
 - Slow spike-and-wave
 - Paroxysmal fast activity
 - Multiple independent spike foci
- Focal
 - Temporal
 - Frontal
 - Centro-parietal
 - Occipital
 - Midline



EEG IN GENERALIZED EPILEPSY SYNDROMES

<u>Syndrome</u>	<u>Epileptiform</u>	<u>Non-Epileptiform</u>
Absence (CAE, JAE)	3-4 Hz SWC +/- polySWC	Normal Background Rhythmic Slow: posterior
Juvenile Myoclonic (JME)	4-5 Hz SWC +/- polySWC	Normal Background
Grand Mal (EGMA)	4-5 Hz SWC +/- polySWC	Normal Background
Lennox Gastaut (LGS)	≤2.5 Hz SWC, polySWC Focal/multifocal spikes Bursts of paroxysmal fast	Background Slow
Myoclonic Astatic (Doose)	2-3 Hz SWC, polySWC	Parietal theta Occipital delta

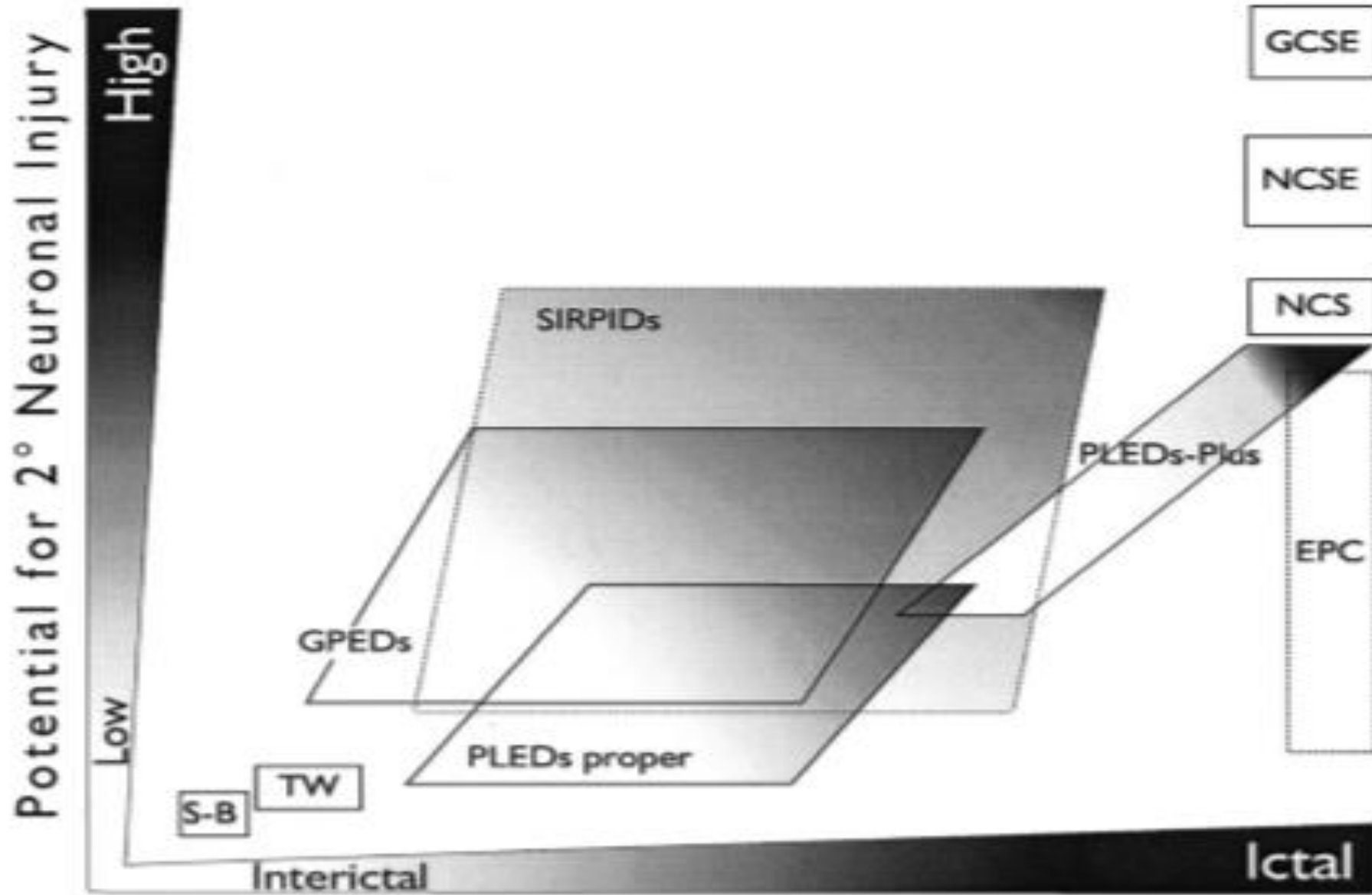


PERIODIC EPILEPTIFORM PATTERNS

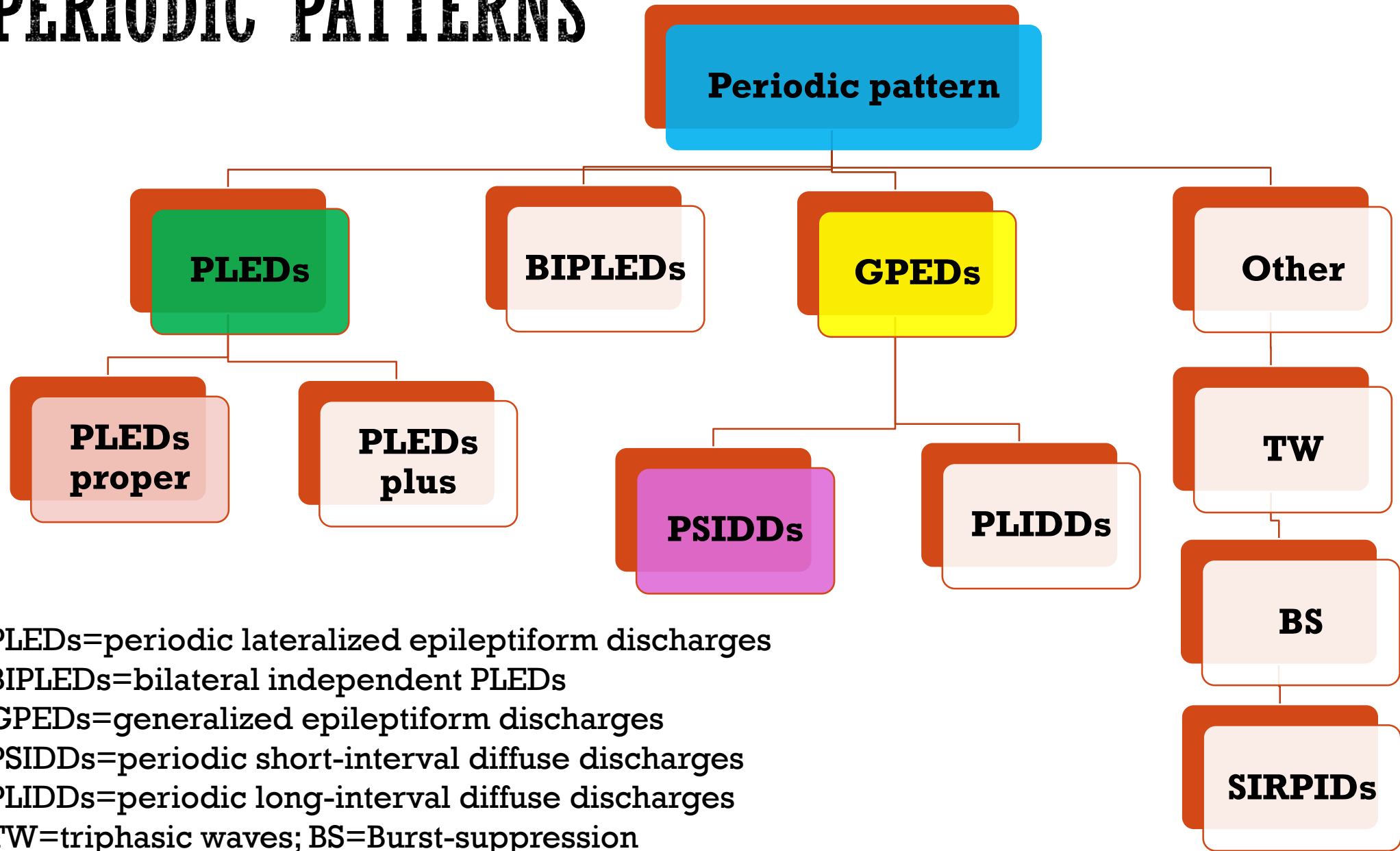
- Questionable epileptiform v.s non epileptiform EEG abnormalities
- consist of various forms discharges, usually epileptiform in appearance, and apply to waves or complexes occurring in sequence at an approximately regular rate or intermittently regular intervals



The Ictal-Interictal-Injury Continuum



PERIODIC PATTERNS



PLEDs=periodic lateralized epileptiform discharges

BIPLEDs=bilateral independent PLEDs

GPEDs=generalized epileptiform discharges

PSIDDs=periodic short-interval diffuse discharges

PLIDDs=periodic long-interval diffuse discharges

TW=triphasic waves; BS=Burst-suppression

SIRPIDs=stimulus induced rhythmic, periodic or ictal discharges



PERIODIC PATTERNS: CHARACTERISTICS

	PLEDs	BIPLDs	GPEDs	
			PSIDDs	PLIDDs
Inter-discharge interval	Typical: 0.5 to 4 s, up to 8 s	Typical: 0.5 to 4 s, up to 8 s	0.5–4 s	4–30 s
Topography	Lateralized (contralateral spread common)	Independently lateralized	Diffuse	Diffuse
Rate of focal or tonic-clonic seizures	High, approximately 80%	Typically lower than in PLEDs but still high	Variable/unclear but not rare	Rare
Associated myoclonus	Rare	Rare	Common with CJD but often not time-locked	Common with SSPE, time-locked
Mental status	Altered	Altered	Altered	Variable
Outcome*	Variable*	Variable*	Variable*	Variable*
Morphology/other characteristics	Morphology variable. Associated with EPC	Morphology variable	Sharp waves, spikes, polyspikes, or sharply-contoured delta waves	Variable; often complex, stereotyped, polyphasic bursts, lasting 0.5–3 s
Etiology	Acute structural lesion: Infarct, ICH, tumor, infection; occasionally no lesion. After SE. Increased risk with metabolic disturbance. HSE	Anoxia, bilateral acute lesions. Occasionally unilateral or no lesion apparent. HSE	Metabolic encephalopathy, anoxia. NCSE . After SE. Lithium, baclofen, CJD	Toxins (PCP, ketamine barbiturates, anesthetics), anoxia SSPE



PLEDS



F7-1-F7
BIPLSDS

- . - .

P7-O1

Fp2-F8

F8-T8

T8-P8

P8-O2

Fp1-F3

F3-C3

C3-P3

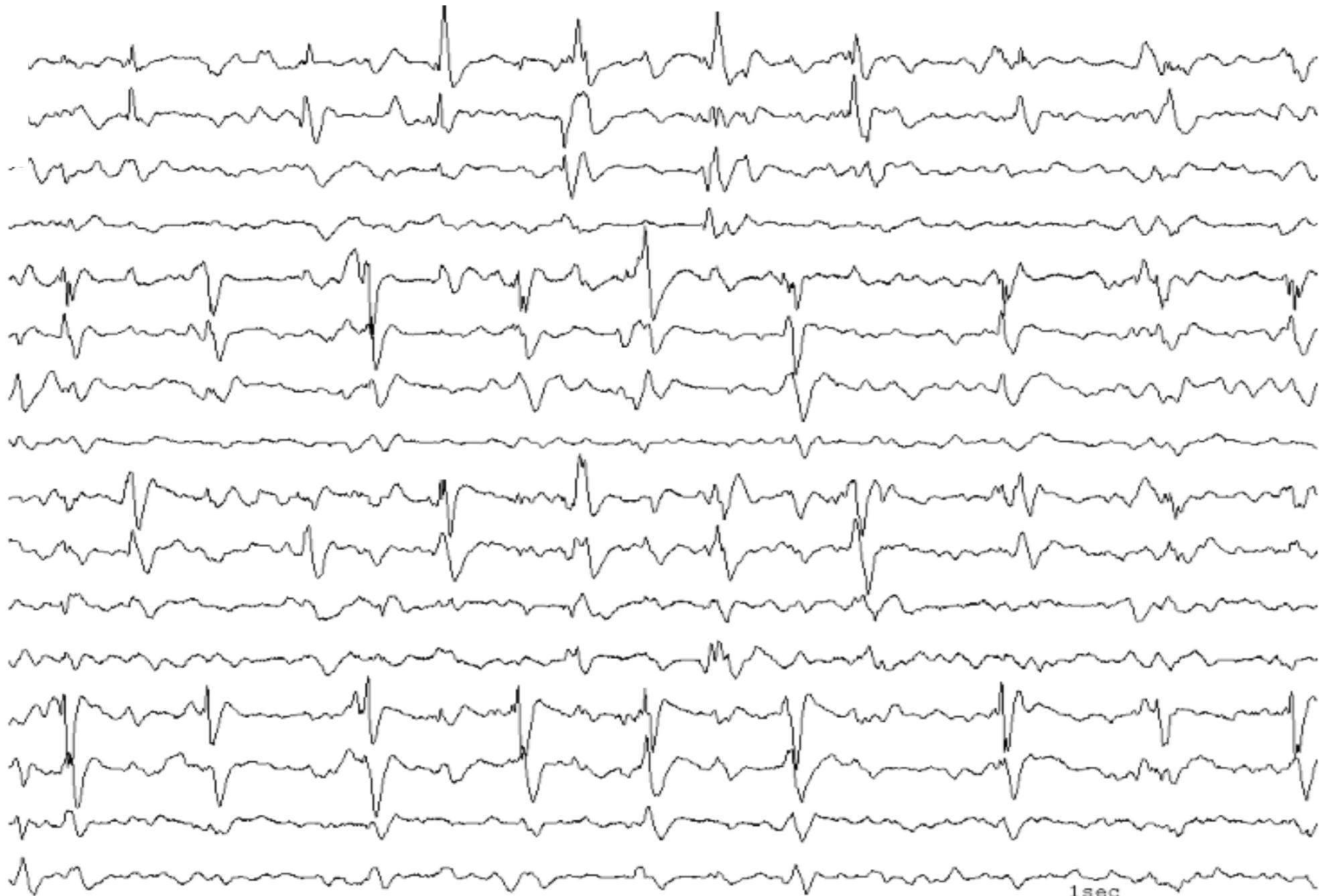
P3-O1

Fp2-F4

F4-C4

C4-P4

P4-O2



1sec

Periodic Pattern: CJD

PSIDDS

P7-A1

I

Fp2-A2

I

F8-A2

I

T8-A2

I

P8-A2

I

F3-A1

I

C3-A1

I

P3-A1

I

O1-A1

I

F4-A2

I

C4-A2

I

P4-A2

I

O2-A2

I

Fz-A2

I

Pz-A2

I

EKG1-EKG2

200 μ V



PLIDDS : SSPE

F_{p1} - A₁
F_{p2} - A₂
C₃ - A₁
C₄ - A₂
O₁ - A₁
O₂ - A₂
T₃ - A₁
T₄ - A₂
F_{p1} - C₃
F_{p2} - C₄
C₃ - O₁
C₄ - O₂
C₃ - T₃
C₄ - T₄
T₃ - F_{p1}
T₄ - F_{p2}



150 μ V
1 sec.

TRIPHASIC WAVES

- Two electronegative waves separated by a positive wave of higher amplitude
- Semi-rhythmic trains at 1.5-2.5 per second, associated with slow background
- Maximum in the frontal and fronto-temporal region, bilaterally synchronous
- Clinical setting : Hepatic encephalopathy, other metabolic encephalopathies, post anoxia, drug intoxication



Fp1-A1
29-47
F9-47

TRIPHASIC WAVE

Fp2-A2

F8-A2

T8-A2

P8-A2

F3-A1

C3-A1

P3-A1

O1-A1

F4-A2

C4-A2

P4-A2

O2-A2

Fz-A2

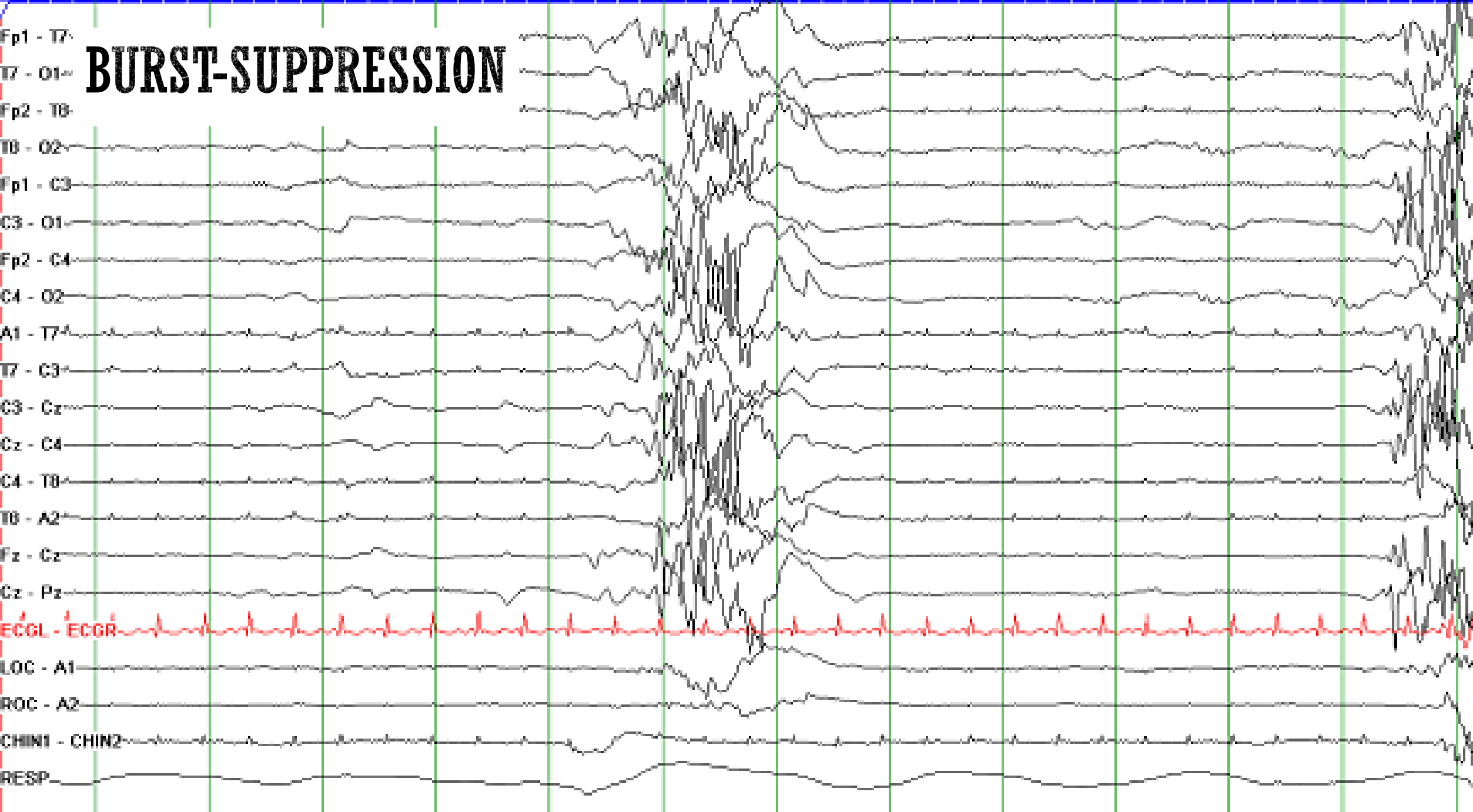


BURST-SUPPRESSION PATTERNS

- Morphology: Periodic, polymorphic, mixed-frequency complexes
- Separated by more or less completely suppressed interburst intervals
- Interburst interval typically 2-10 seconds (may last several minutes)
- Usually bilaterally synchronous
- Clinical setting: under anesthesia or drug overdose, also association with cardiac arrest, hypothermia, anoxia



BURST-SUPPRESSION



STIMULUS INDUCED RHYTHMIC, PERIODIC OR ICTAL DISCHARGES (SIRPIDS)

- Ictal appearing discharges induced by alert stimuli e.g. auditory stimuli, sternal rub, examination, suction, turning, and other patient care activities
- Unclear seizure relations

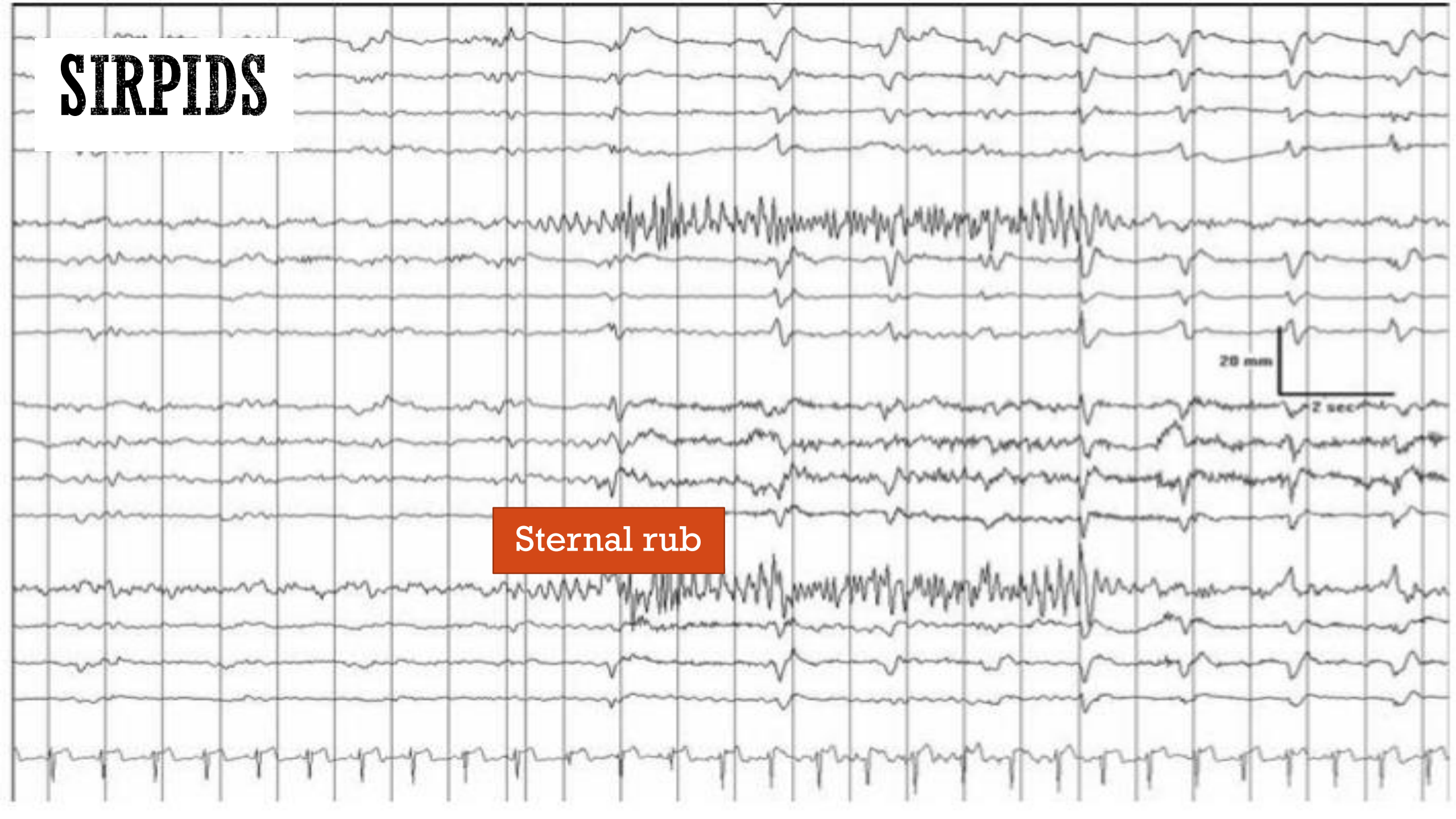


SIRPIDS

Sternal rub

20 mm

2 sec



CONCLUSION: DIAGNOSTIC USE OF INTERICTAL EEG

- Aids in establishing whether epilepsy is present
- Helps classify whether a focal or generalized seizure disorder is present
- Assists defining specific syndrome, e.g., rolandic epilepsy, childhood absence epilepsy, Lennox-Gastaut syndrome

Pillai J, Spering RM, Epilepsia, 47(suppl.1):14-22, 2006

