Epileptiform Abnormalities

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Chiang Mai, Thailand

Objectives

- To discuss the type and features of interictal epileptiform discharges (Focal VS Generalized)
- To discuss their clinical correlation

Interictal Epileptiform Discharges (IED)

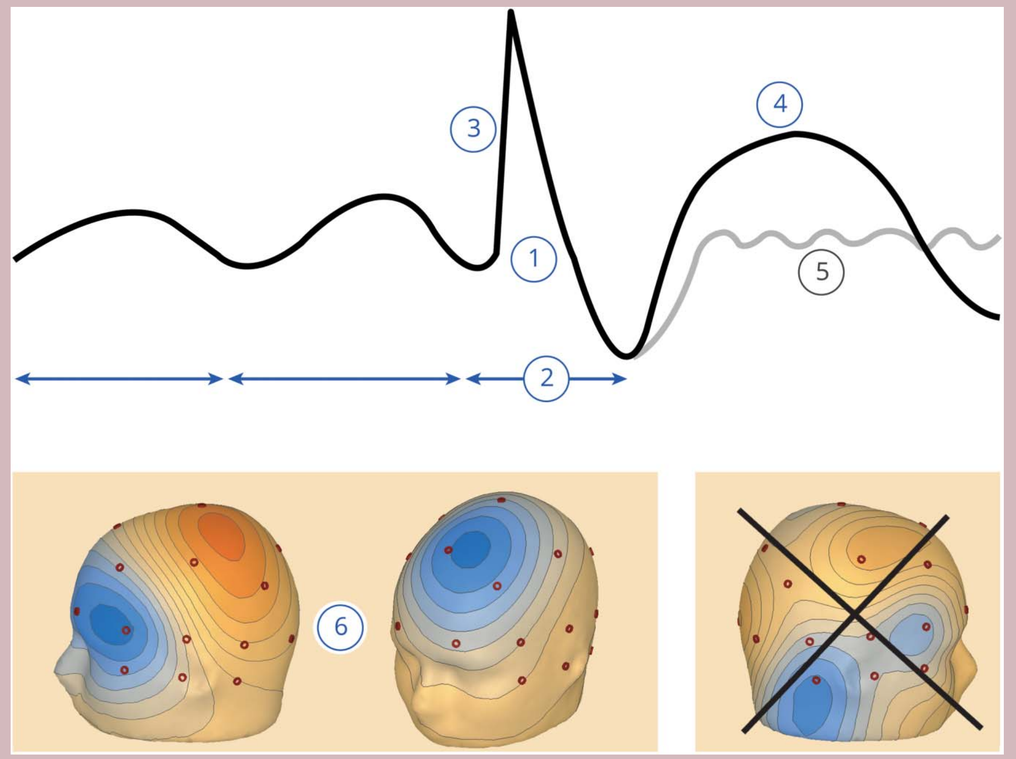
“ Distinctive waveforms or complexes resembling those recorded in a proportion of human subjects suffering from epileptic disorders and in animals rendered experimentally ”

Chatrian G,, et al, International Federation of Societies for Electroencephalography and Clinical Neurophysiology, ed., 1983:11–27.

Fulfill at least 4 of the 6 criteria

1. Di- or tri-phasic waves with sharp or spiky morphology (i.e. pointed peak).
2. Different wave-duration than the ongoing background activity, either shorter or longer.
3. Asymmetry of the waveform: a sharply rising ascending phase and a more slowly decaying descending phase, or vice versa.
4. The transient is followed by an associated slow after-wave.
5. The background activity surrounding epileptiform discharges is disrupted by the presence of the epileptiform discharges.
6. Distribution of the negative and positive potentials on the scalp suggests a source of the signal in the brain, corresponding to a radial, oblique or tangential orientation

IED



Kane N, et al. Clin Neurophysiol Pract 2017;2:170–185.

IED

- EEG abnormalities are associated with a predisposition to experiencing or developing epileptic seizures
- The presence of epileptiform discharges does not necessarily indicate the patient has a seizure disorder
- Vary with age, stage, medication, activation procedure

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Seizure

- Taken together with the clinical history and other diagnostic test results
- The frequency of IED is not necessarily associated with the severity of epilepsy
- IEDs may help classify epilepsy or epilepsy syndrome or localized epileptogenic zone

Sam M et al. Epilepsia 2001;42:1273–1277.

Focal IED

- Spikes
- Sharp waves
- Polyspikes
- LPDs
- TIRDA

Generalized IED

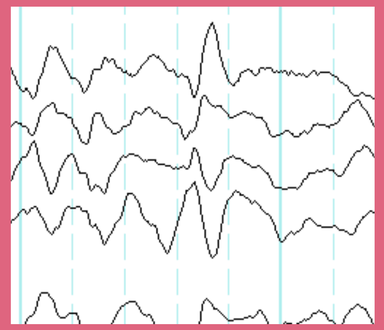
- 3-Hz Spike-and-wave
- Atypical Spike-and-slow-wave
- Slow spike-and-wave discharges
- Generalized repetitive fast discharge (GFRD)
- Hypsarrhythmia

Focal IED

Sharp waves

70 - 200 MILLISECONDS

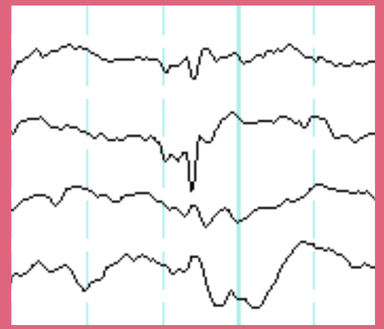
- Amplitude varies
- Does not apply distinctive physiological events such as Vx, lambda waves and POSTs



Spikes

20-70 MILLISECONDS

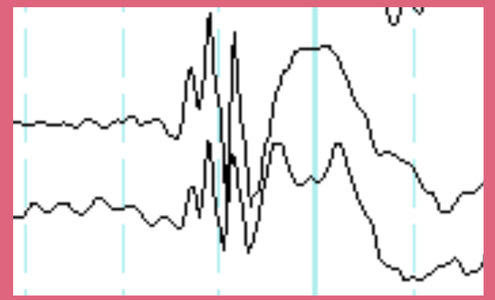
- Amplitude varies but typically > 50 mV



Polyspikes

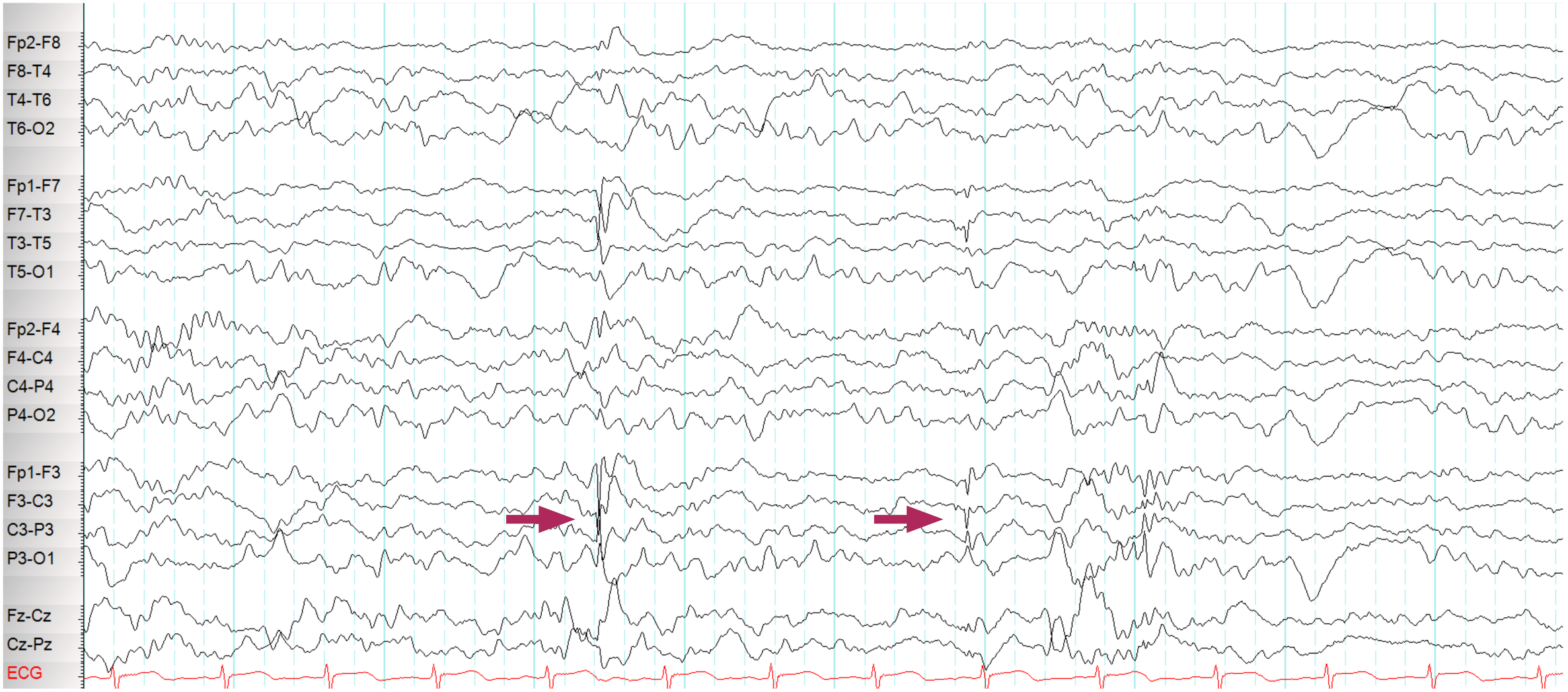
70 - 200 MILLISECONDS

- A Multiple spikes in rapid succession, typically at frequencies of 10 Hz or faster, maybe followed by slow wave

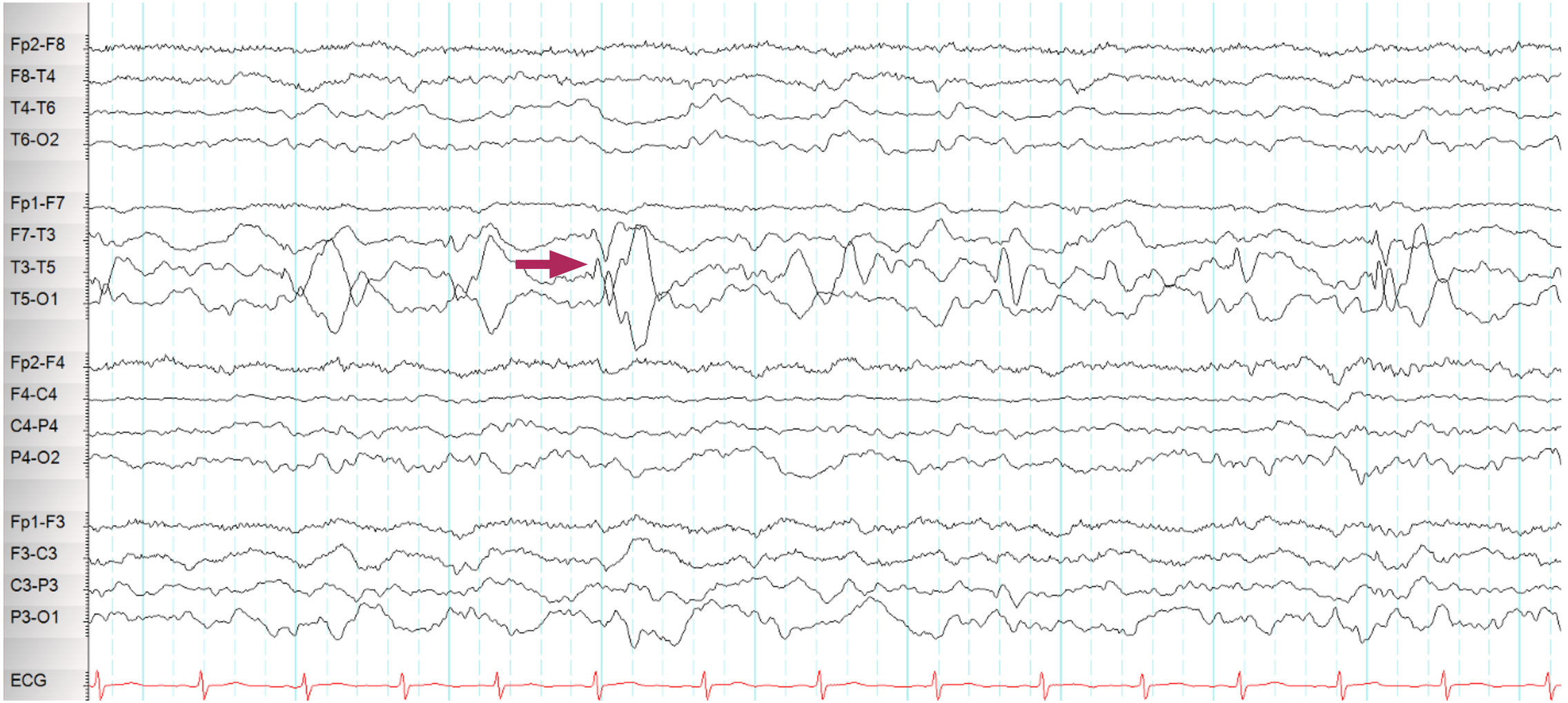


Kane N, et al. Clin Neurophysiol Pract 2017;2:170–185.

Spikes


Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fz-Cz
Cz-Pz
ECG

Sharp waves


Fp2-F8
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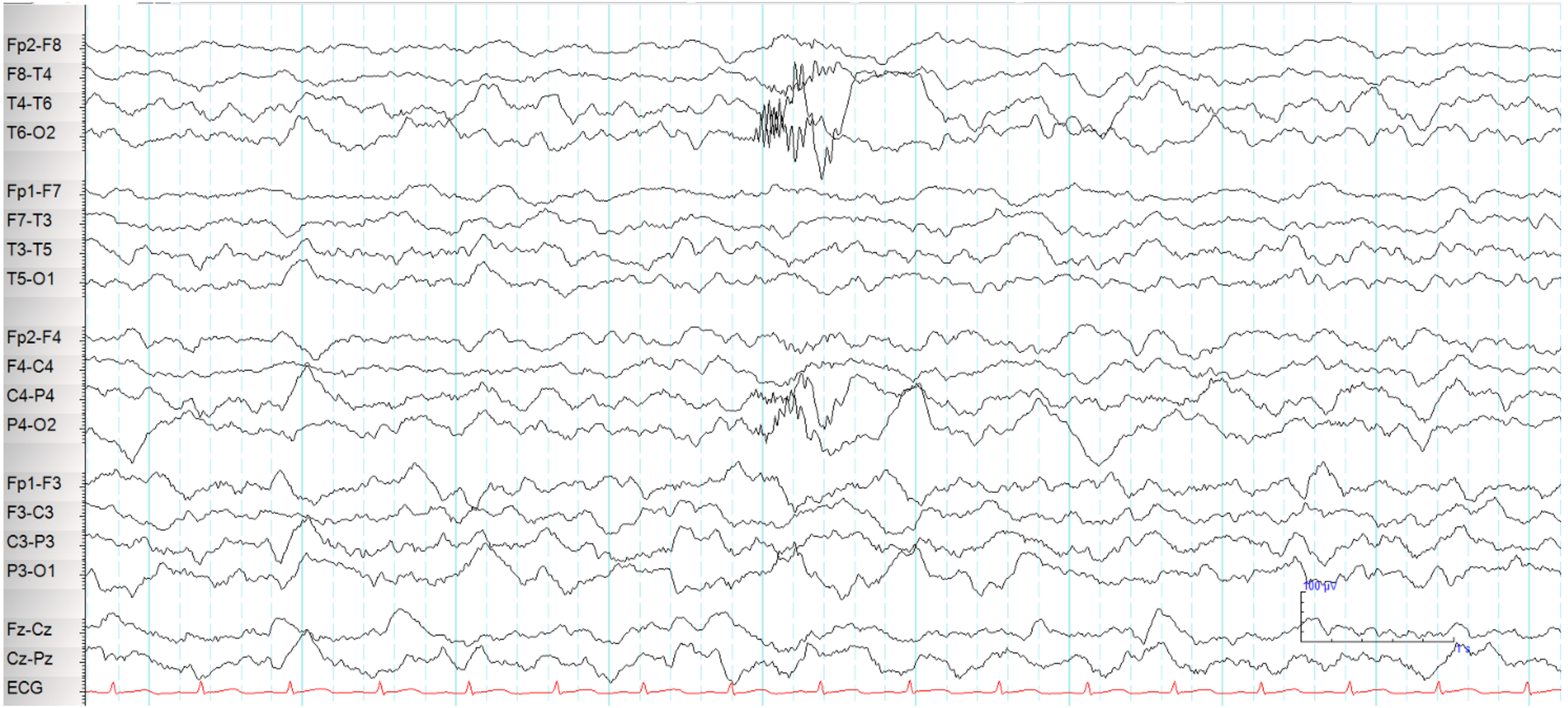
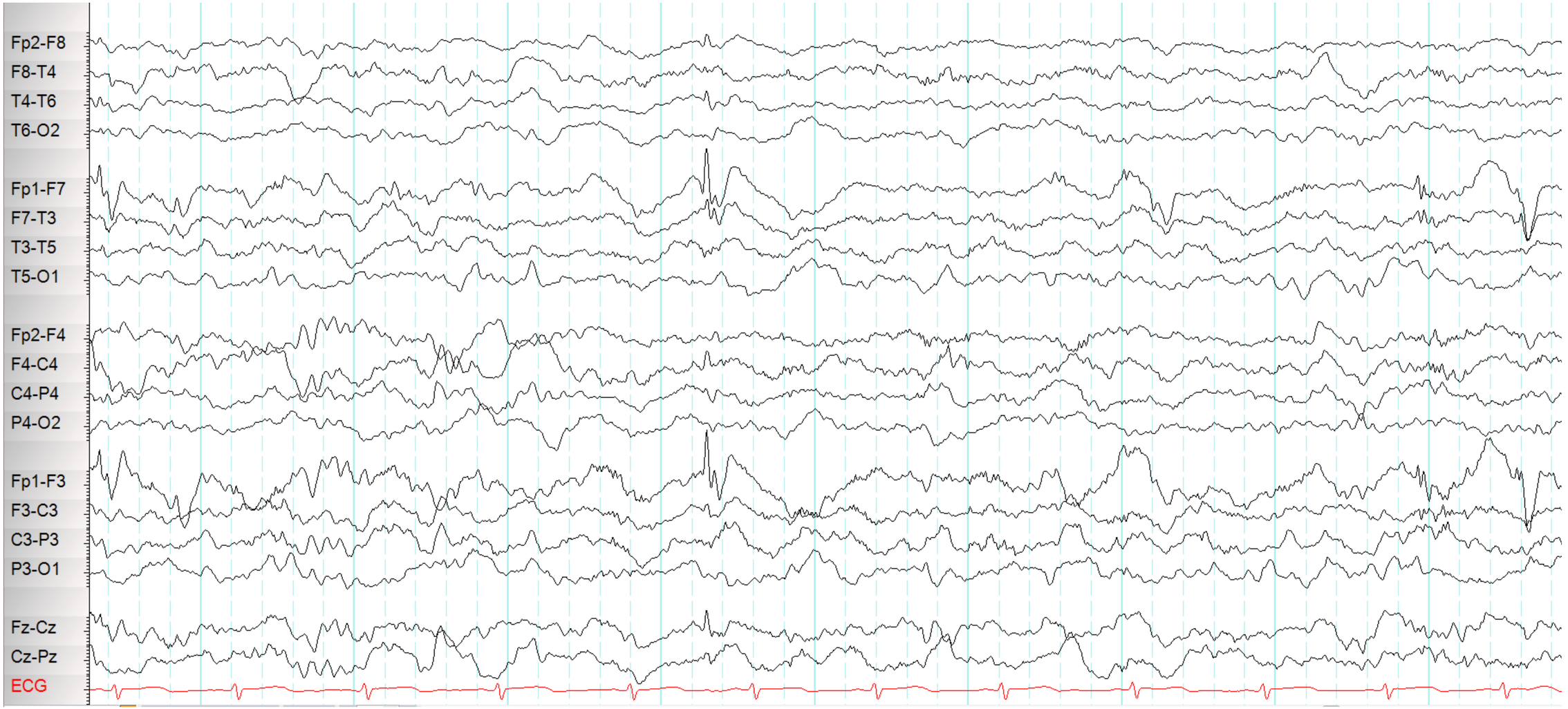
T4-T6
T6-O2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
ECG

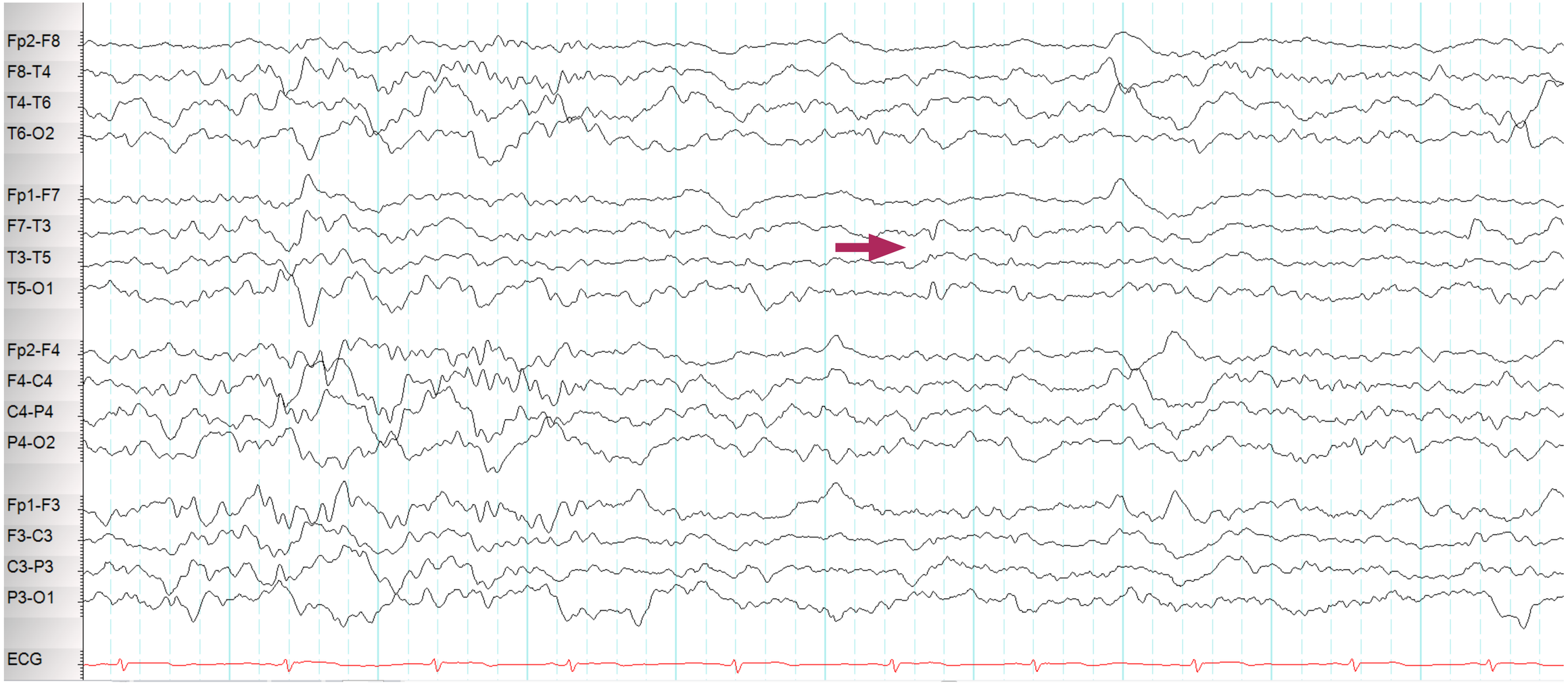
Polyspikes


Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fz-Cz
Cz-Pz
ECG
100 µV
1 s

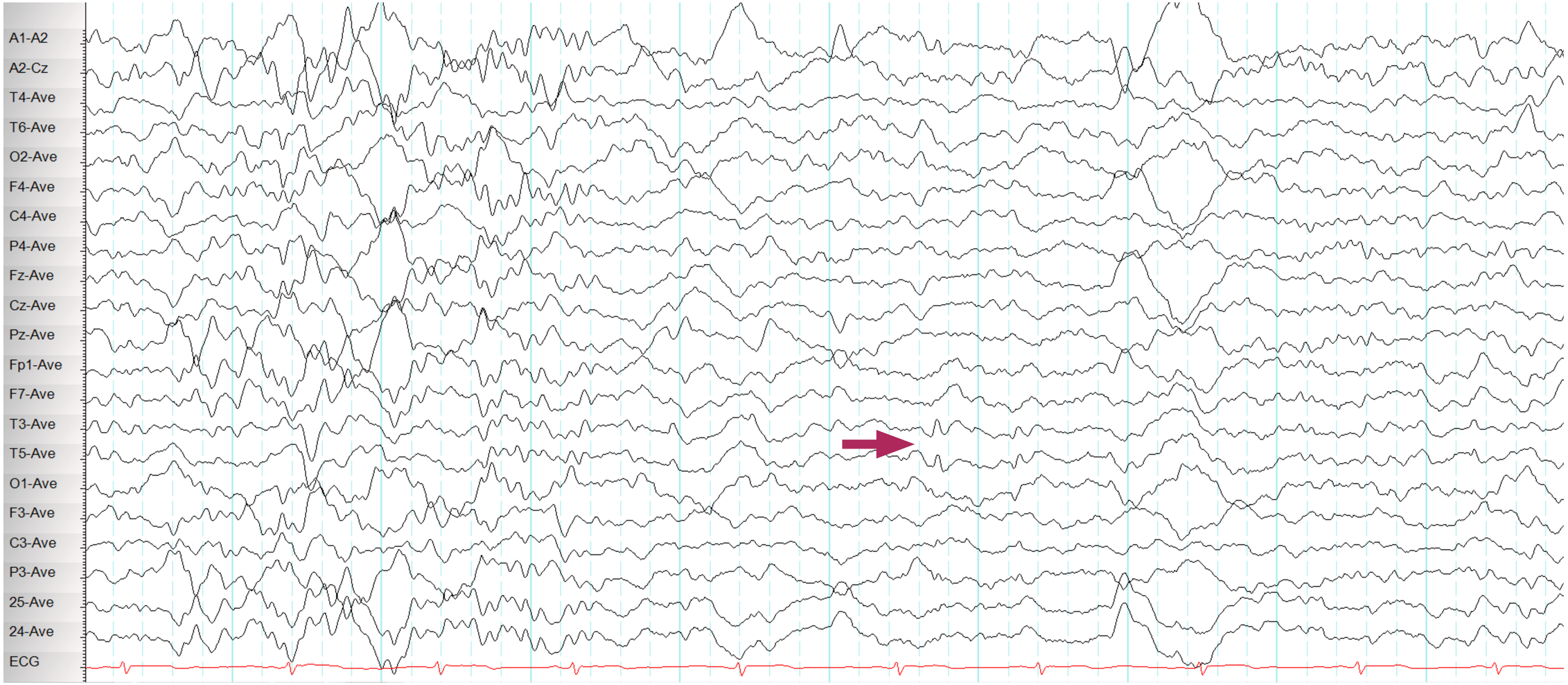
Spike-and-slow-wave complex : Left frontal



Bi-polar montage



Average montage



Focal spikes/sharp waves : Location

- Common Location : Temporal > frontal > centrotemporal > parietal > occipital > midline central and/or paracentral

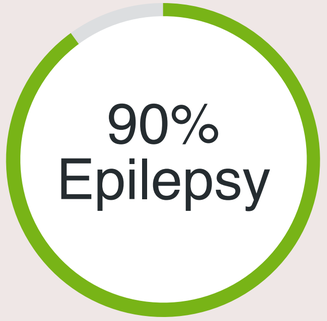
- Spike distribution depends on age: Occipital (mostly young children under 3–5), Central-parietal (mostly age 3–8), Central-temporal (Rolandic-Sylvian) (mainly occur at age 4–12), Anterior temporal (most often seen in adults but may start at age 12–15)

Slatter K., et al. Brain 1968;91:85–91.
Fois A,, et al. Epilepsia 1988;29:620–623.
Kellaway P,, et al.Electroencephalogr Clin Neurophysiol 1955;7:469–478.

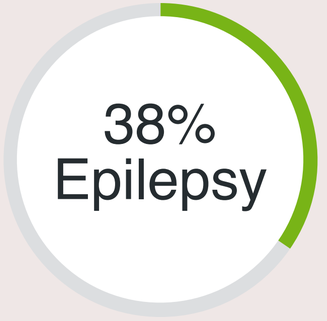
Focal spikes/sharp waves : Location

- The association with focal epilepsy is higher for temporal spikes/sharp waves than rolandic or occipital spikes/sharp waves

- Occipital IEDs can be seen in migraine or children with congenital blindness, without seizures (Needle spikes)



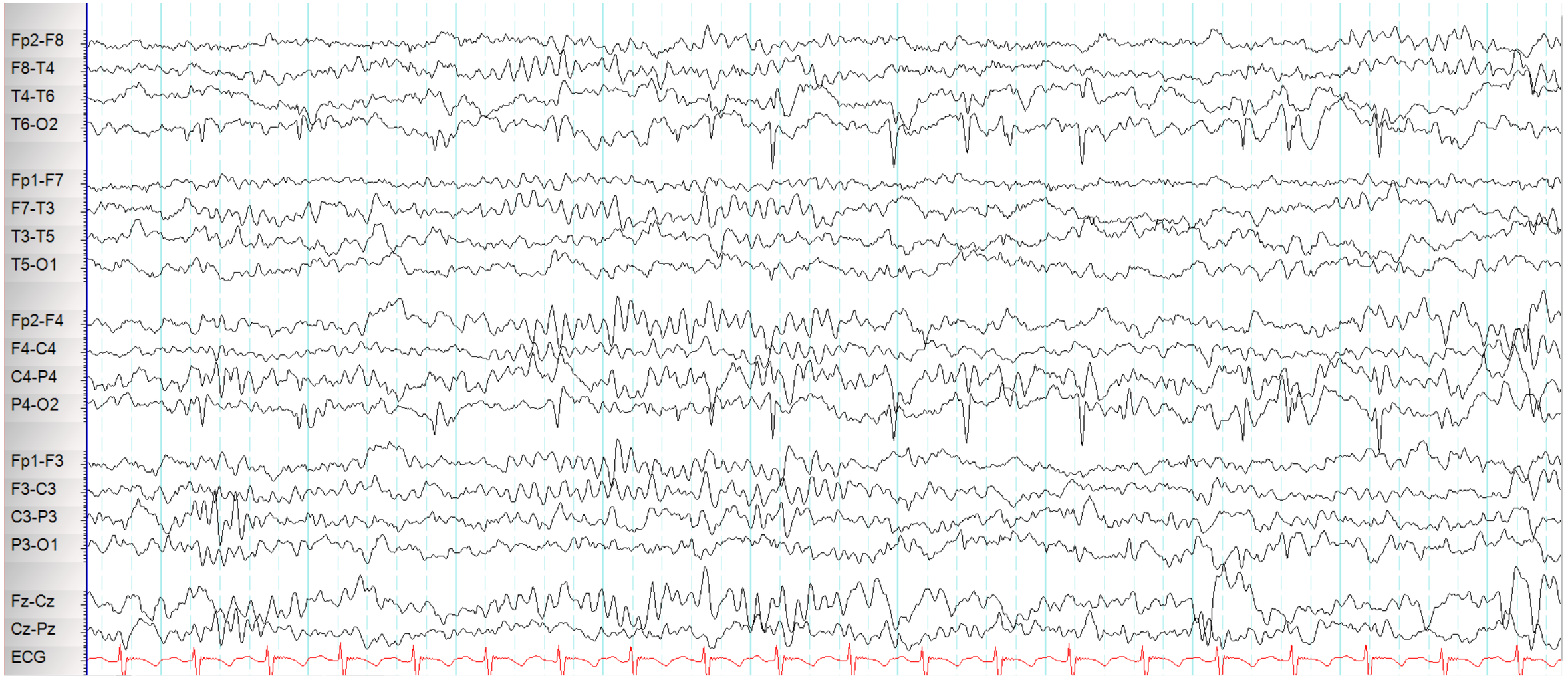
ANTERIOR TEMPORAL SPIKES/SHARP WAVES



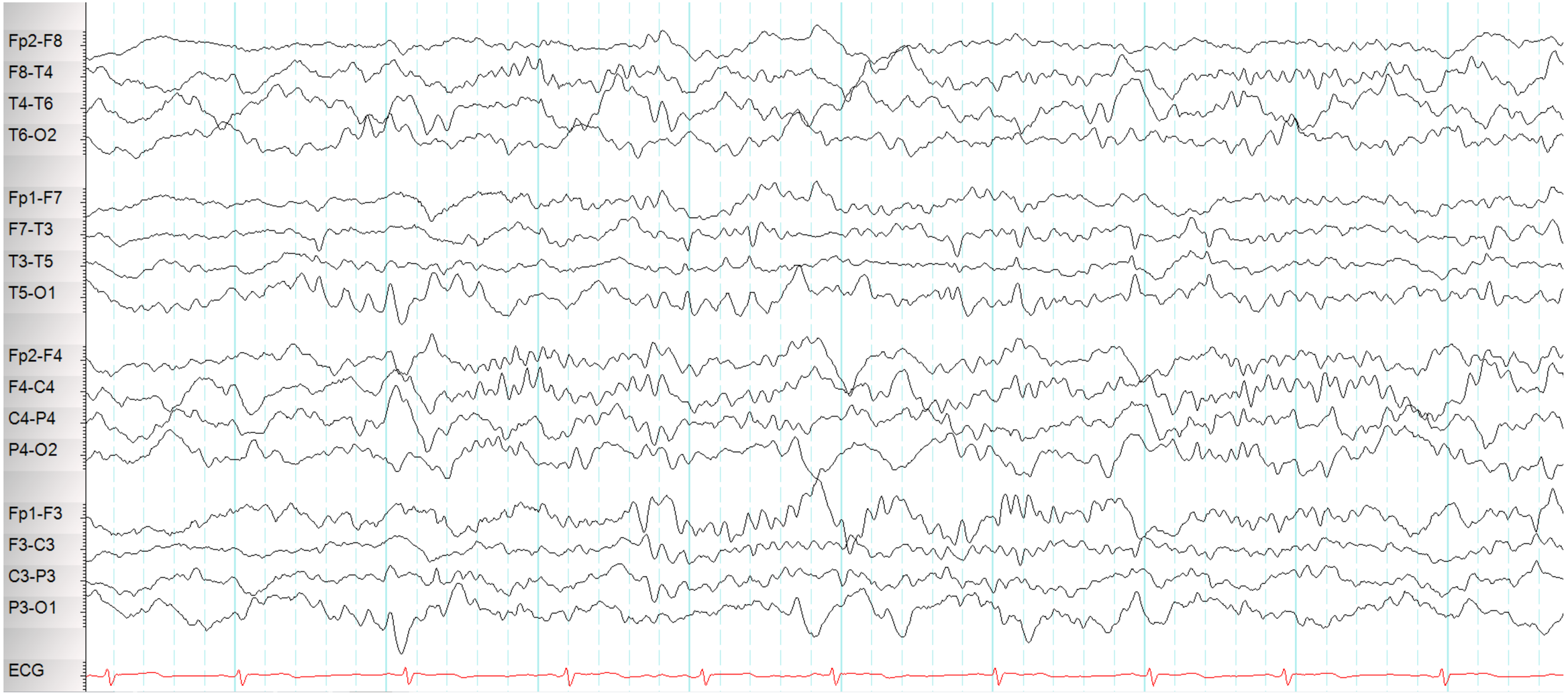
ROLANDIC SPIKES/SHARP WAVES

Slatter K., et al. Brain 1968;91:85–91.
Fois A,, et al. Epilepsia 1988;29:620–623.
Kellaway P,, et al.Electroencephalogr Clin Neurophysiol 1955;7:469–478.

Spikes : right occipital



Sharp waves : left temporal



Focal spikes/sharp waves

- Most focal spikes/sharp waves are surface negative
- Positive spikes/sharp waves are not common in adults
  - Site of craniotomy
  - Newborn with intraventricular hemorrhage or leukomalacia
  - Young children with multifocal spikes/sharp waves in global encephalopathy such as with ischemic injury or lipid storage disease

Matsuo F, et al. Electroencephalogr Clin Neurophysiol 1977;42:15–25.
Marret S, et al. Neuropediatrics 1986;17:199–202.

Positive sharp waves

Focal spikes/sharp waves in benign, age-related syndrome

- Typical morphology, distribution and activation factors in benign, age-related syndrome
  - Benign epilepsy of childhood with centrotemporal spikes or benign rolandic epilepsy
  - Benign childhood epilepsy with occipital paroxysms
  - Early-onset Childhood Seizures with Occipital Spikes (Panayiotopolous syndrome)

Caraballo R, et al. Neurology 2000;55:1096–1100.

BRE/BECTs


Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fz-Cz
Cz-Pz
ECG

BRE/BECTs


Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fz-Cz
Cz-Pz
ECG

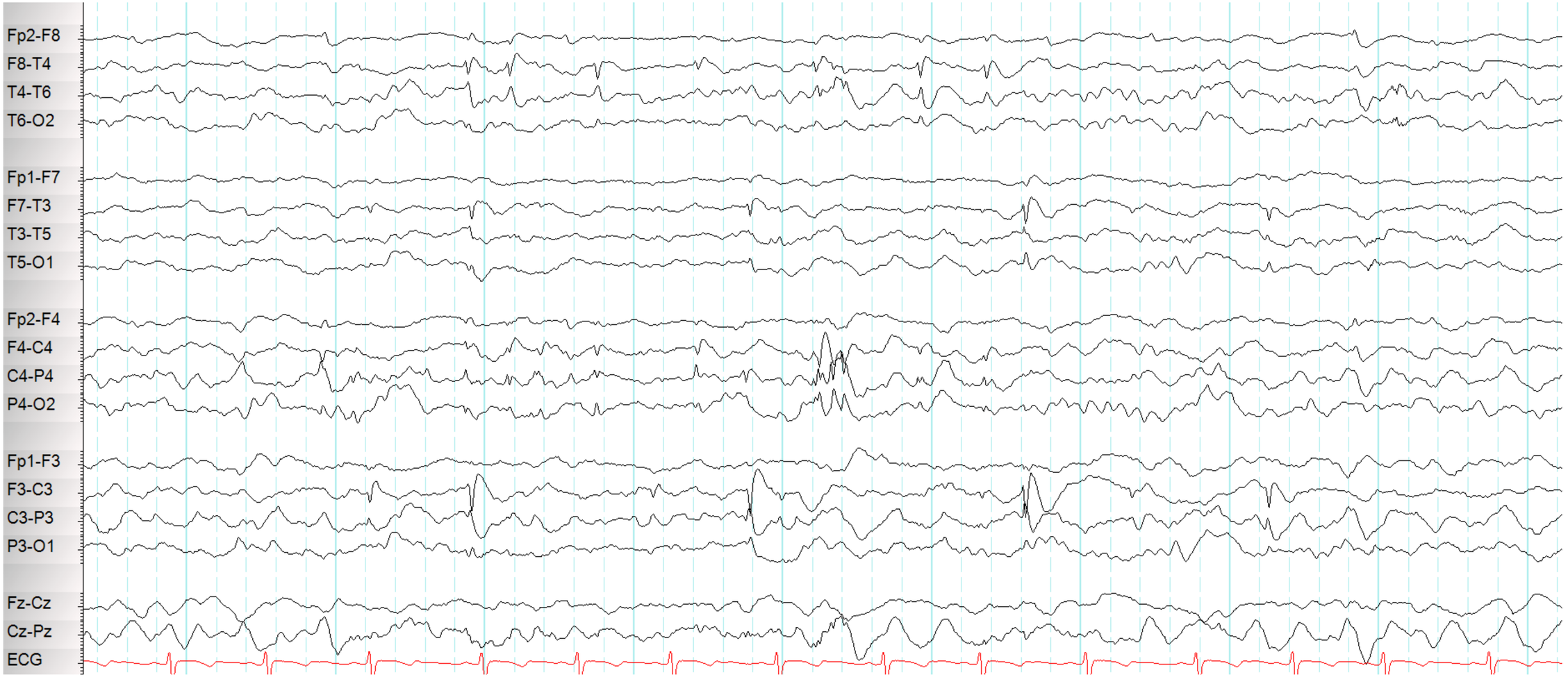
Multifocal spikes/Sharp waves

- Multiple independent foci of spikes or sharp waves involved both hemisphere
- Can be seen at any age, frequently in children aged 4 - 7 years
- Nearly all of them have EEG background slowing
- 94% of them have seizures; generalized motor seizures are the most common (76%), and

  50% have daily seizure
- 82% have mental retardation and developmental delays
- Association with structural brain abnormalities or history of brain injury

Noriega-Sanchez A,, et al. Neurology 1976;26:667–672.

Multifocal spikes

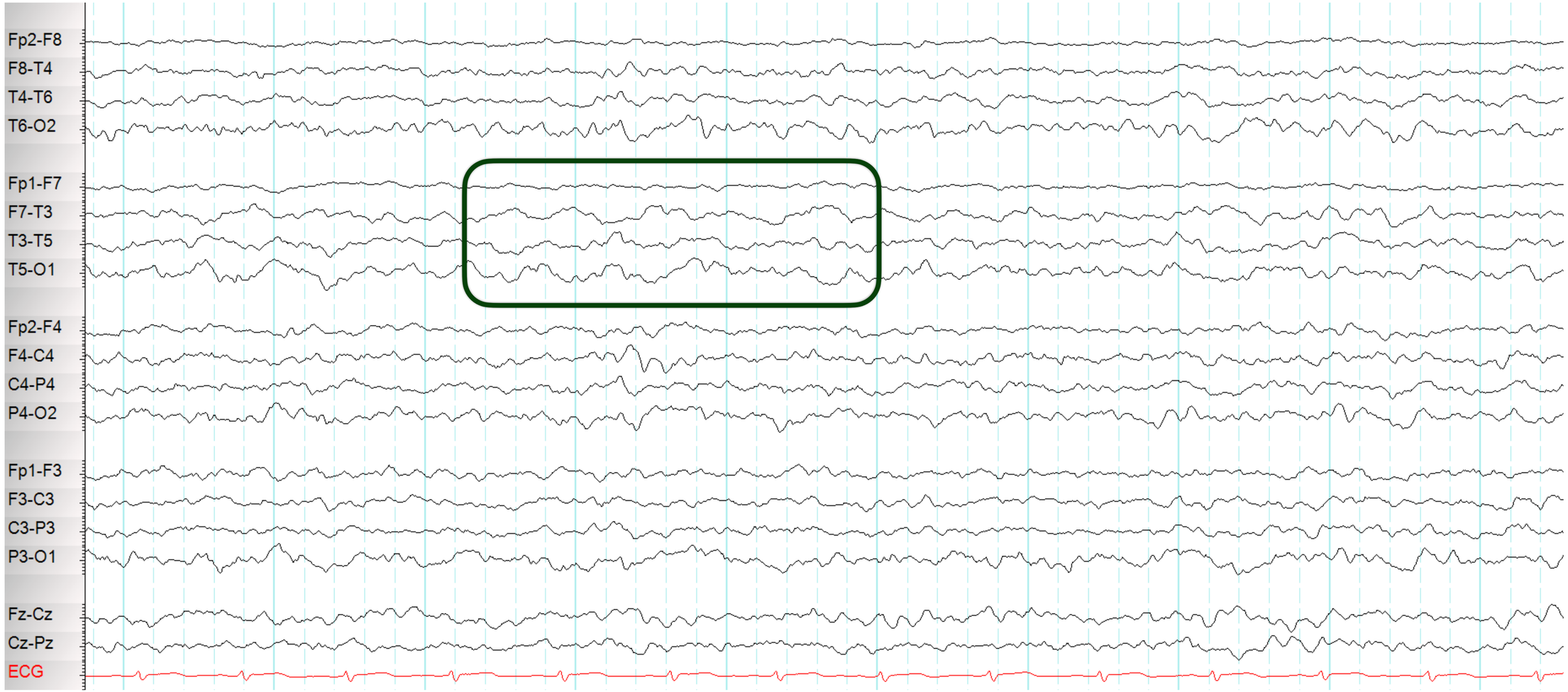


Temporal Intermittent Rhythmic Delta Activity (TIRDA)

- Intermittent sinusoidal train of rhythmic delta waves from the temporal region, last several seconds, common frequency is 2 - 3 Hz
- Seen in awake and sleep, prominent in drowsiness
- Highly associated with temporal lobe seizures and/or underlying structural lesions (2/3 of patients)
- Temporal depth electrode recording during TIRDA (on the scalp) showed active spiking activity in amygdalohippocampal structures

Reiher J, et al, Can J Neurol Sci 1989;16:398–401.
Normand M, et al. J Clin Neurophysiol 1995;12:280–284.

TIRDA


Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fz-Cz
Cz-Pz
ECG

Periodic Lateralized Epileptiform Discharges (PLEDs) or Lateralized periodic discharges (LPDs)

- Unilateral surface negative discharges (spike/sharp/sharp slow-wave) that recur with regular periodicity, usually every 0.3 - 0.4 seconds, monophasic or polyphasic
- Focal, regional or diffusely affecting the entire hemisphere, the interval between PLEDs lengthens over days-weeks, common location TPO regions
- Highly associated with acute cerebral disorders, especially structural lesions such as stroke, trauma, herpes encephalitis, tumor, and abscess, and > 50% of patients will develop seizure
- Rare cause; metabolic encephalopathy, CJD, migraine, and toxic encephalopathy (aminophylline or alcohol intoxication)

Chatrian C, et al, Electroencephalogr Clin Neurophysiol 1964;17:177–193.
Kane N, et al. Clinical neurophysiology practice. 2017;2:170.

Periodic Lateralized Epileptiform Discharges (PLEDs) or Lateralized periodic discharges (LPDs)

- **PLEDs-plus** carries a much higher association with clinical seizures and status epilepticus compared to PLEDs-proper

- **BIPLEDs or BIPDs**= bilaterally discharges, dependent or independent, seen in patients with severe hypoxic encephalopathy or bilateral hemisphere destructive lesions

- **Multifocal PLEDs or MfLDs** = at least 3 foci of periodic activity involving two hemisphere - etiologies; multifocal strokes, infection.,etc.-90% of patients who have seizure

- **Generalized periodic discharges (GPDs)** are common findings after SE (in children) and anoxic brain, sepsis, stroke, infection (in adult)

Chatrian C, et al, Electroencephalogr Clin Neurophysiol 1964;17:177–193.
De La Paz D, et al. Arch Neurol 1981;38:713–715.

Periodic Lateralized Epileptiform Discharges (PLEDs) or Lateralized periodic discharges (LPDs)

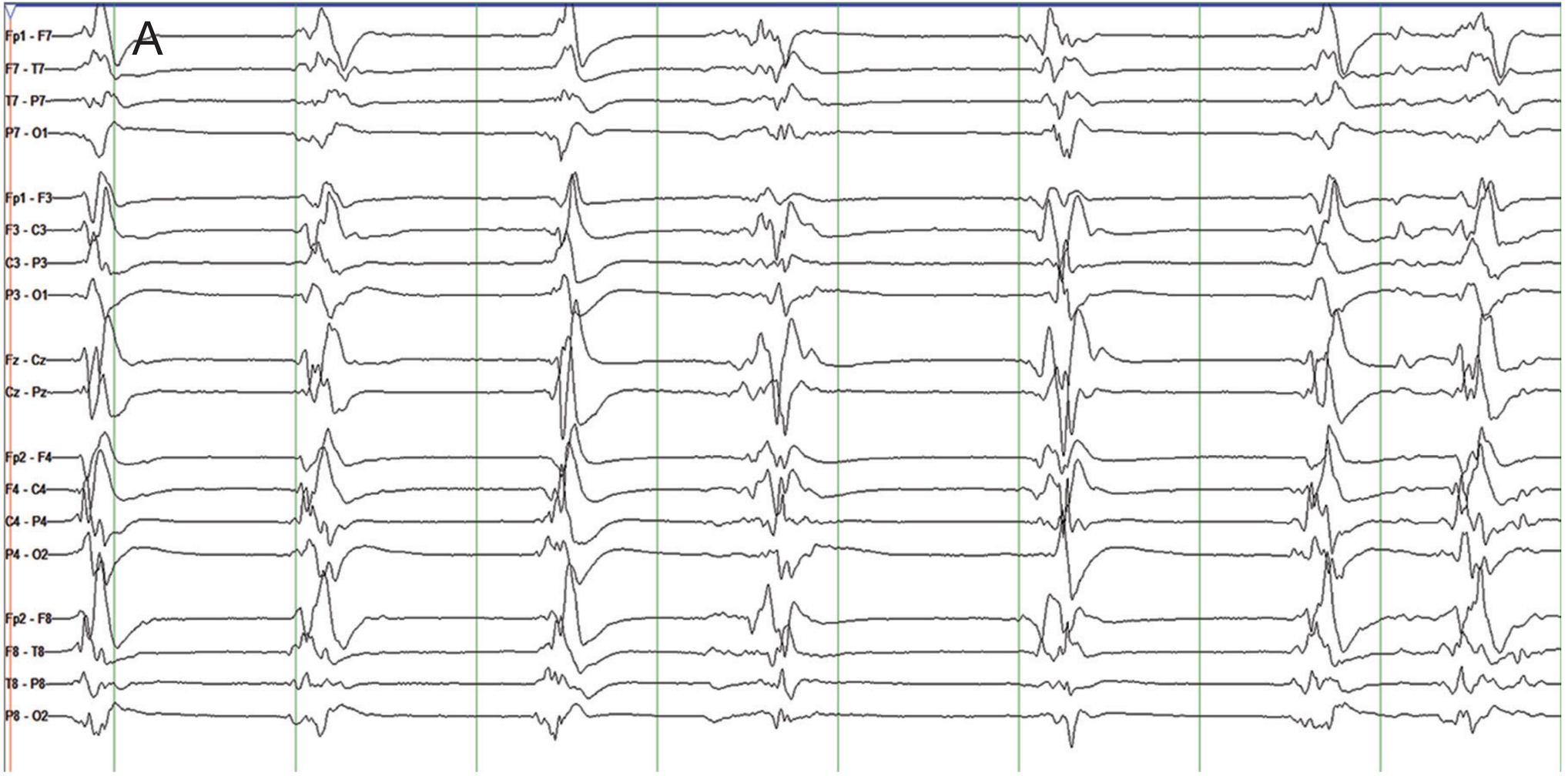
- **Plus (+)**
  - “+F”: with superimposed (some prefer the synonyms of admixed or associated) fast activity, defined as theta or faster, whether rhythmic or not.
  - “+R”: with superimposed rhythmic or quasi-rhythmic delta activity; can be applied to PDs only
  - “+S”: with associated sharp waves or spikes, or sharply contoured; can be applied to RDA only

Hirsch LJ, et al. ACNS’s standardized critical care EEG terminology: 2021 version. 2021.

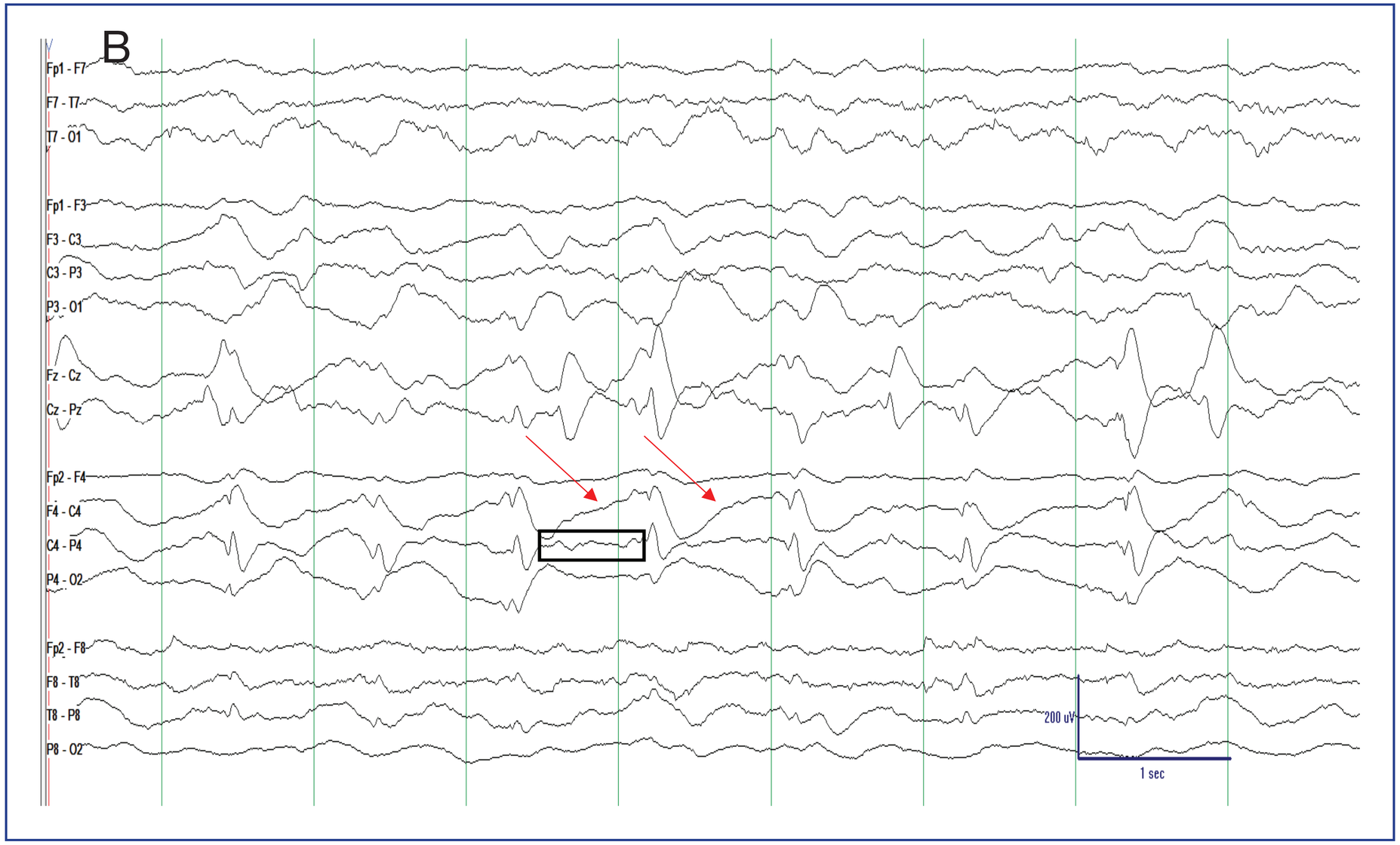
BIPDs


FP1-F3
F3-C3
C3-P3
P3-O1
FP2-F4
F4-C4
C4-P4
P4-O2
FP1-F7
F7-T3
T3-T5
T5-O1
FP2-F8
F8-T4
T4-T6
T6-O2
100 uV
1 sec

GPDs


A
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
Fp2 - F8
F8 - T8
T8 - P8
P8 - O2

LPDs plus


B
Fp1 - F7
F7 - T7
T7 - 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
200 uV
1 sec

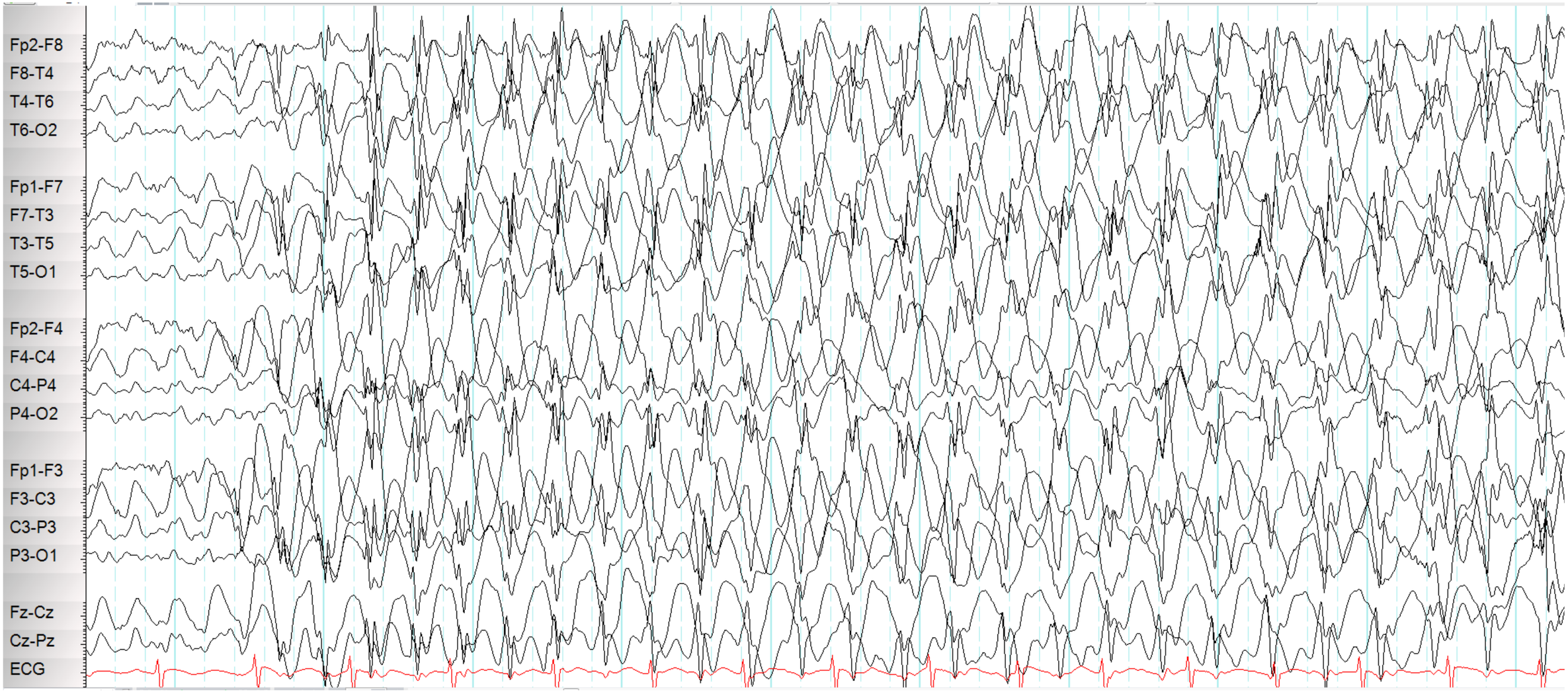
Generalized IED

3 Hz Spike-and-Wave

- Bilateral spikes and after-coming slow waves -repeat rhythmically at a rate of three cycles per second
- Burst lasts 1-3 seconds, or longer when activated by hyperventilation or drowsiness
- Synchronous in timing and symmetry- the difference between hemispheres can be detected, but no more than 20 milliseconds
- Amplitude prominent in midline frontal area
- EEG signature of absence epilepsy, brief burst can interfere with mental functioning
- Must be aware of Pseudo-absence events

Penry J,, et al. Brain 1975;98:427–440.
Lafleur J,, et al. Electroencephalogr Clin Neurophysiol 1977;43:279–280.

3 Hz Spike-and-Wave

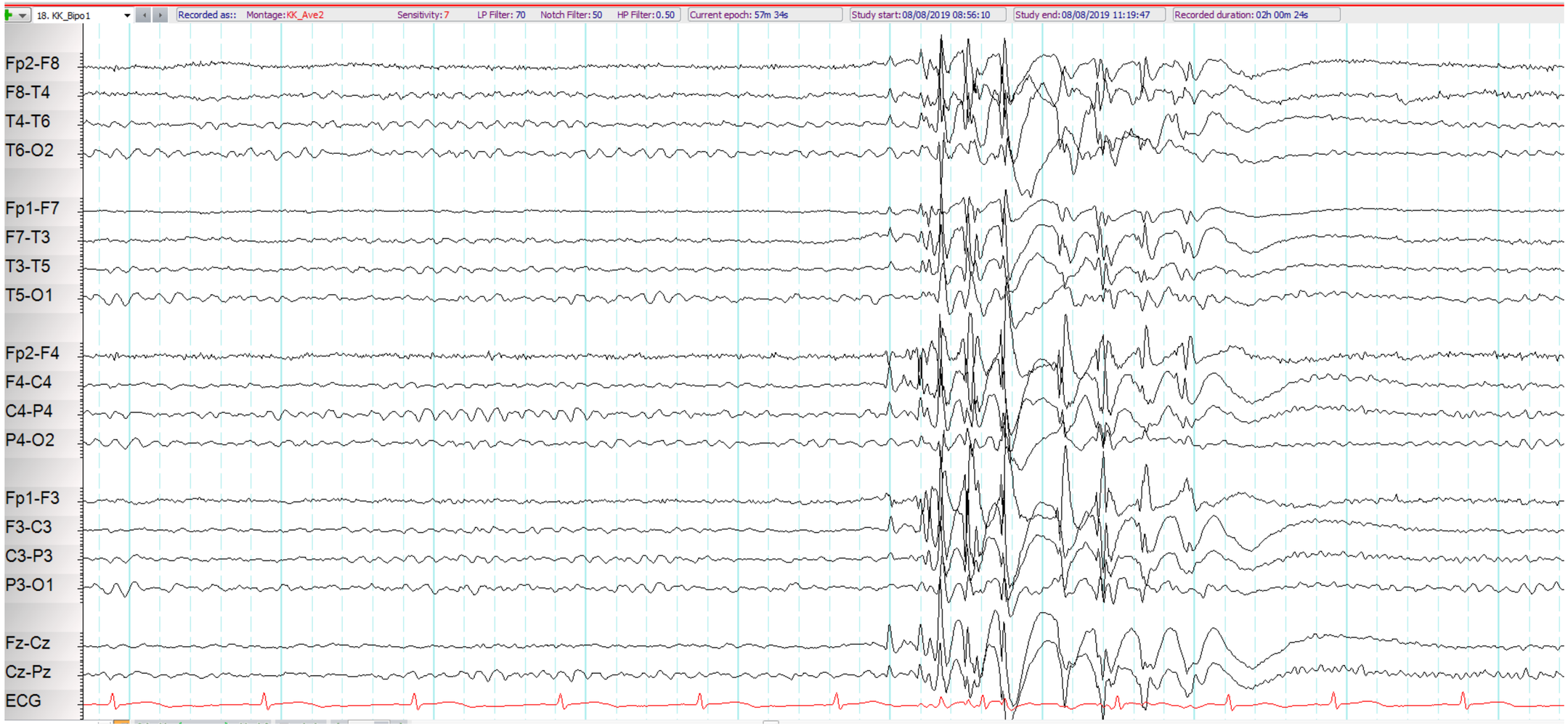


Generalized Atypical Spike-and-Slow-Waves

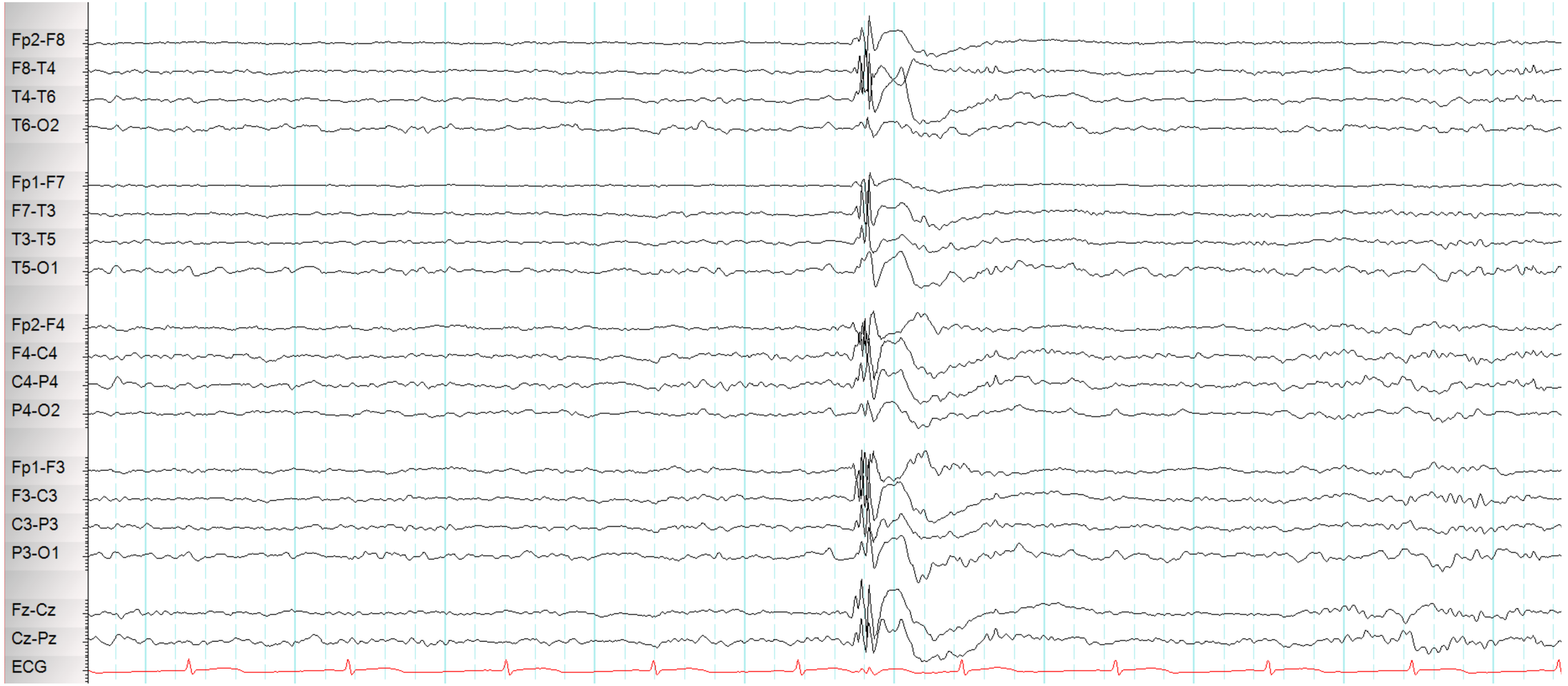
- Resemble 3-Hz spike-and-waves discharges, but variable rates and spike component is often polyphasic
- Amplitude and morphology vary within and between bursts
- Enhanced by drowsiness and non-REM sleep
- Clinical correlation with primary generalized epilepsy - benign myoclonic epilepsy of early childhood, juvenile myoclonic epilepsy (JME), juvenile absence epilepsy and photosensitive epilepsy

Binnie C,, et al. Clinical neurophysiology of epilepsy. Amsterdam, the Netherlands: Elsevier, 1990:263–290.

Generalized Atypical Spike-and-Slow-Waves



Generalized Polyspikes-and-Slow-Waves Complex

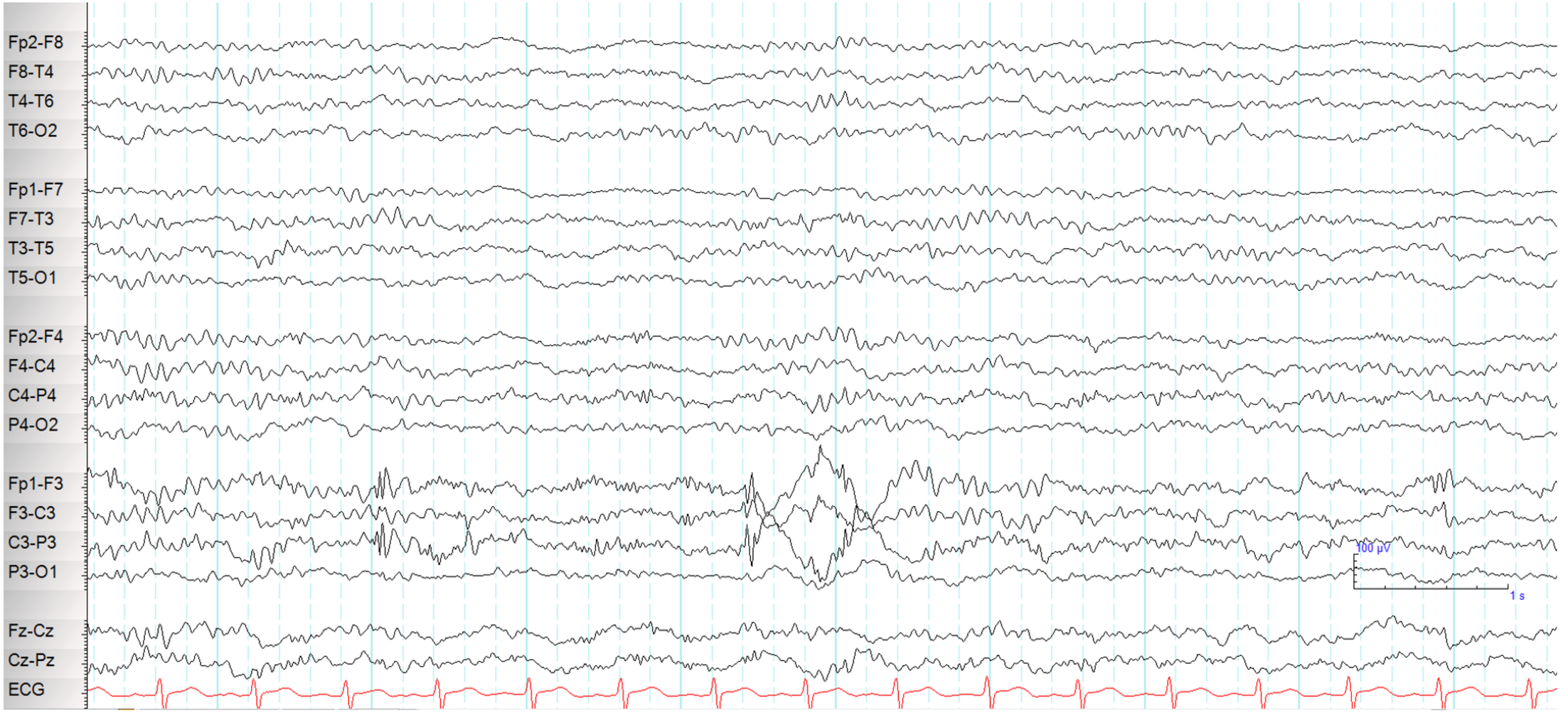


3-Hz and atypical spike-and-slow-waves

- Both 3-Hz and atypical spike-and-slow-waves : focal spikes of low amplitude in the frontal and temporal areas during drowsiness
- Do not indicate a focal epilepsy, as long as they are not abundantly present in single location during wakefulness or sleep.

Binnie C,, et al. Clinical neurophysiology of epilepsy. Amsterdam, the Netherlands: Elsevier, 1990:263–290.

Focal spikes

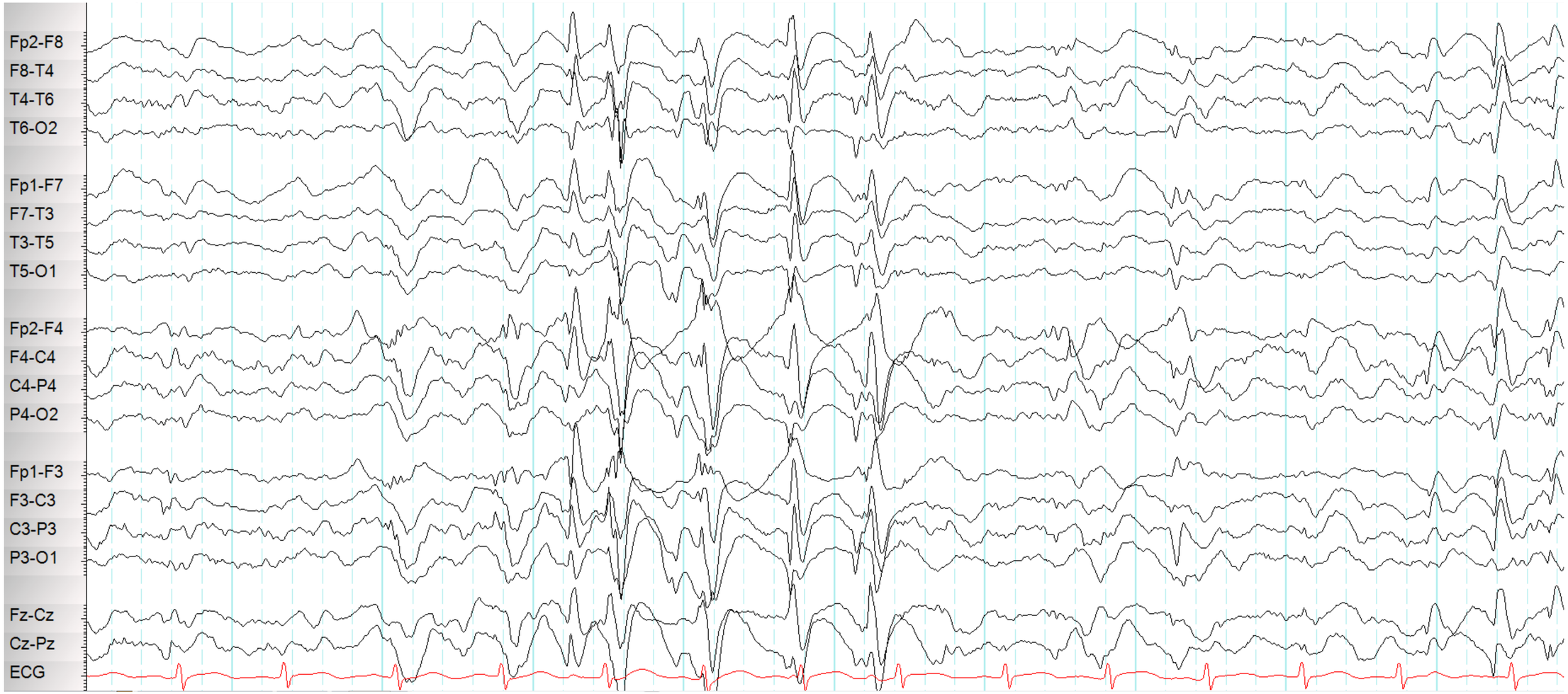


Slow Spike-and-Waves
(Sharp-and-Slow-Wave Complexes)

- Frequency around 1-2.5 Hz, mostly sharp waves - wide duration and blunt peaks
- Fluctuating asymmetry of amplitude is common
- Drowsiness or non-REM sleep may activated train -similar to ESES
- Enhanced by HV but not photic
- Commonly seen in Lennox-Gastaut syndrome (LGS)

Gastaut H,, et al. Electroencephalogr Clin Neurophysiol Suppl 1982;(35):71–84.

Sharp-and-Slow-Wave Complexes



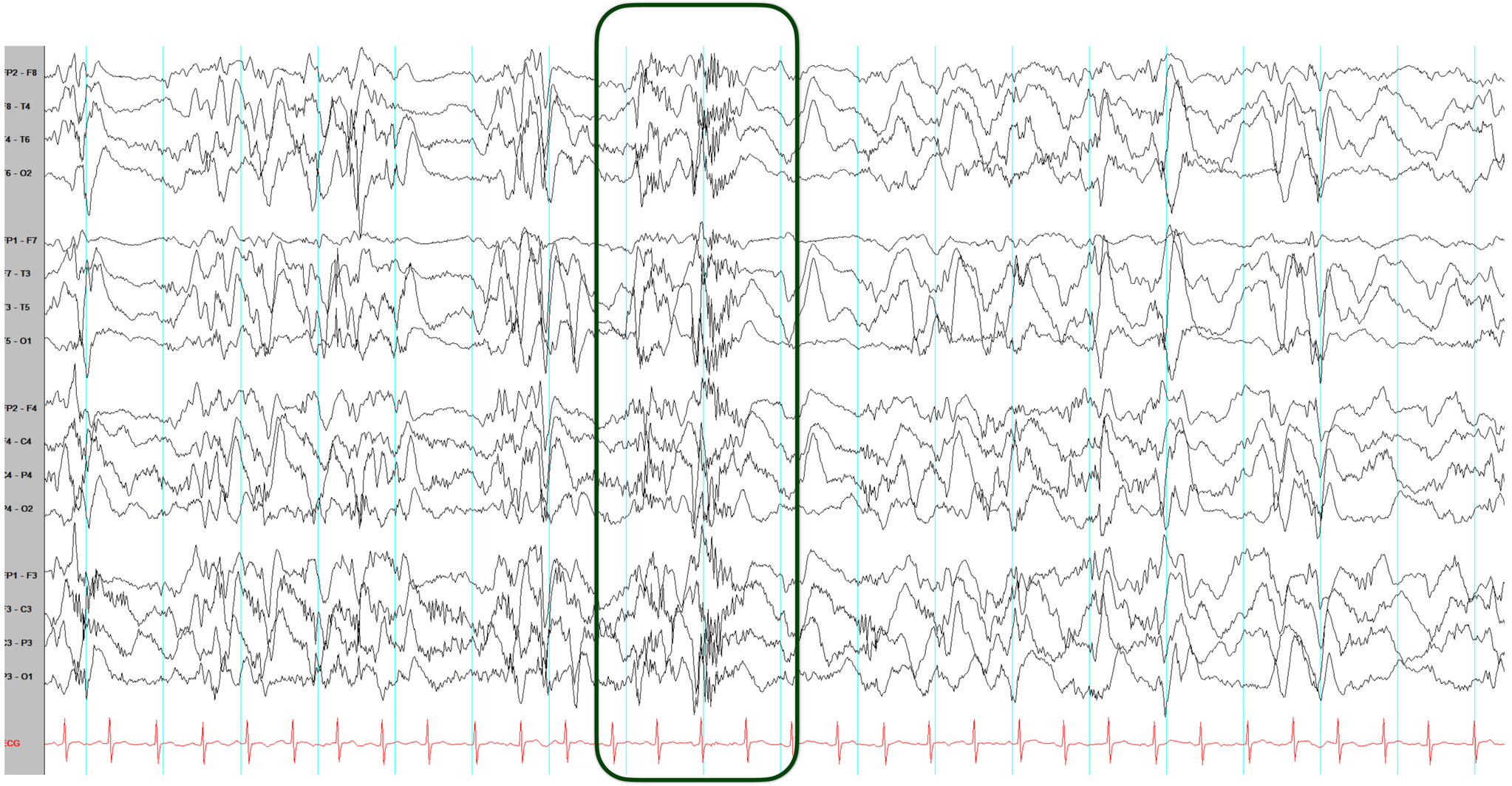
Sharp-and-Slow-Wave Complexes

Generalized Repetitive Fast Discharge (GRFD)

- Paroxysmal fast rhythm, generalized paroxysmal fast activity, or “runs of rapid spikes”
- Alpha or beta frequency range
- Generalized, low-to-medium amplitude, last less than 10 seconds
- Most GRFD occurs during sleep
- May be preceded or followed by generalized slow spike-and-wave discharge
- Considered an ictal rhythm- could be accompanied by tonic seizure
- Often associated with catastrophic epilepsy syndrome

Halasz P., et al. Degen R, Rodin E, eds. Epilepsy, sleep and sleep deprivation. Amsterdam, the Netherlands: Elsevier Science Publishers B.V., 1991:49–71.

Generalized Repetitive Fast Discharge (GRFD)



Hypsarrhythmia

- High-voltage background composed of disorganized slow theta and delta frequencies is seen in addition to nearly continuous multi-focal interictal epileptiform discharges
- Associated with epileptic spasm

Gibbs FA, Gibbs EL. Atlas of Electroencephalography. Reading (MA): Addison-Wesley; 1952.

Hypsarrhythmia

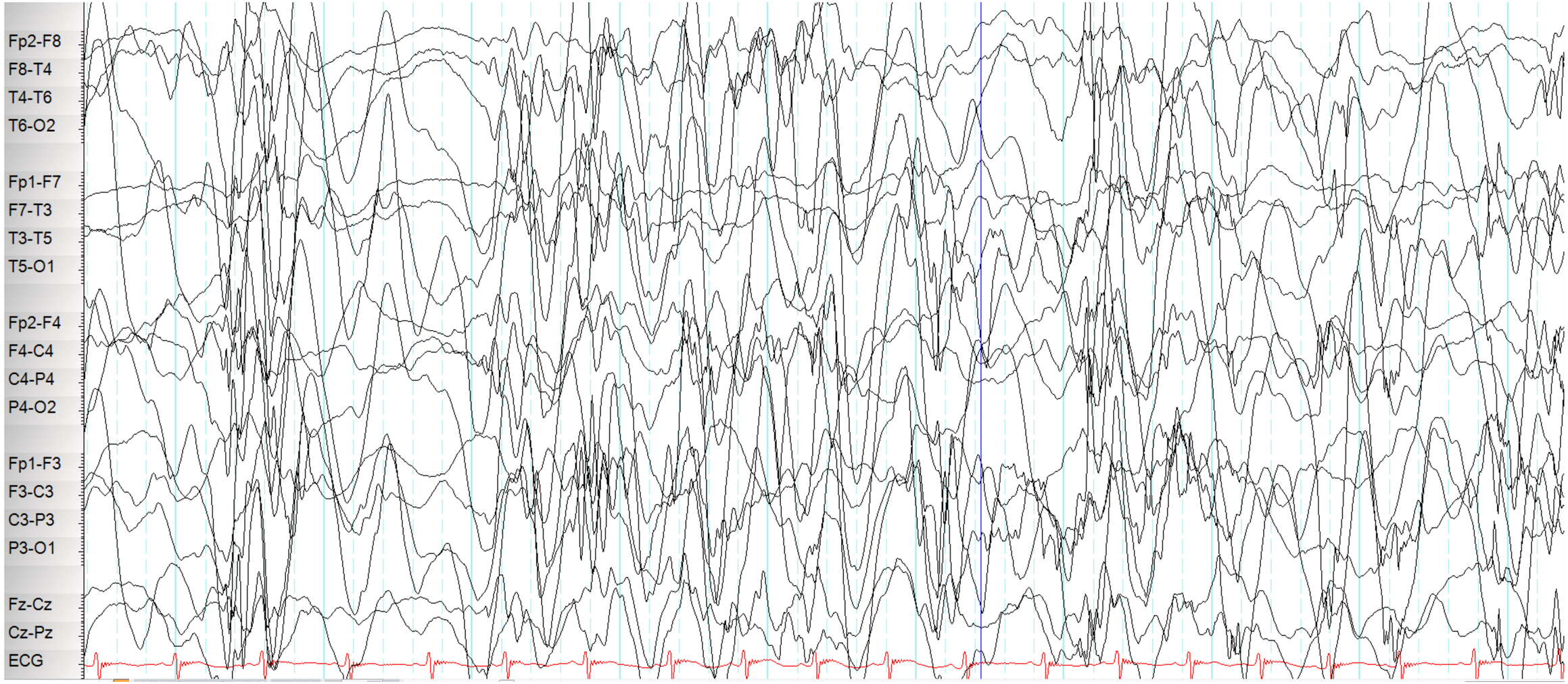
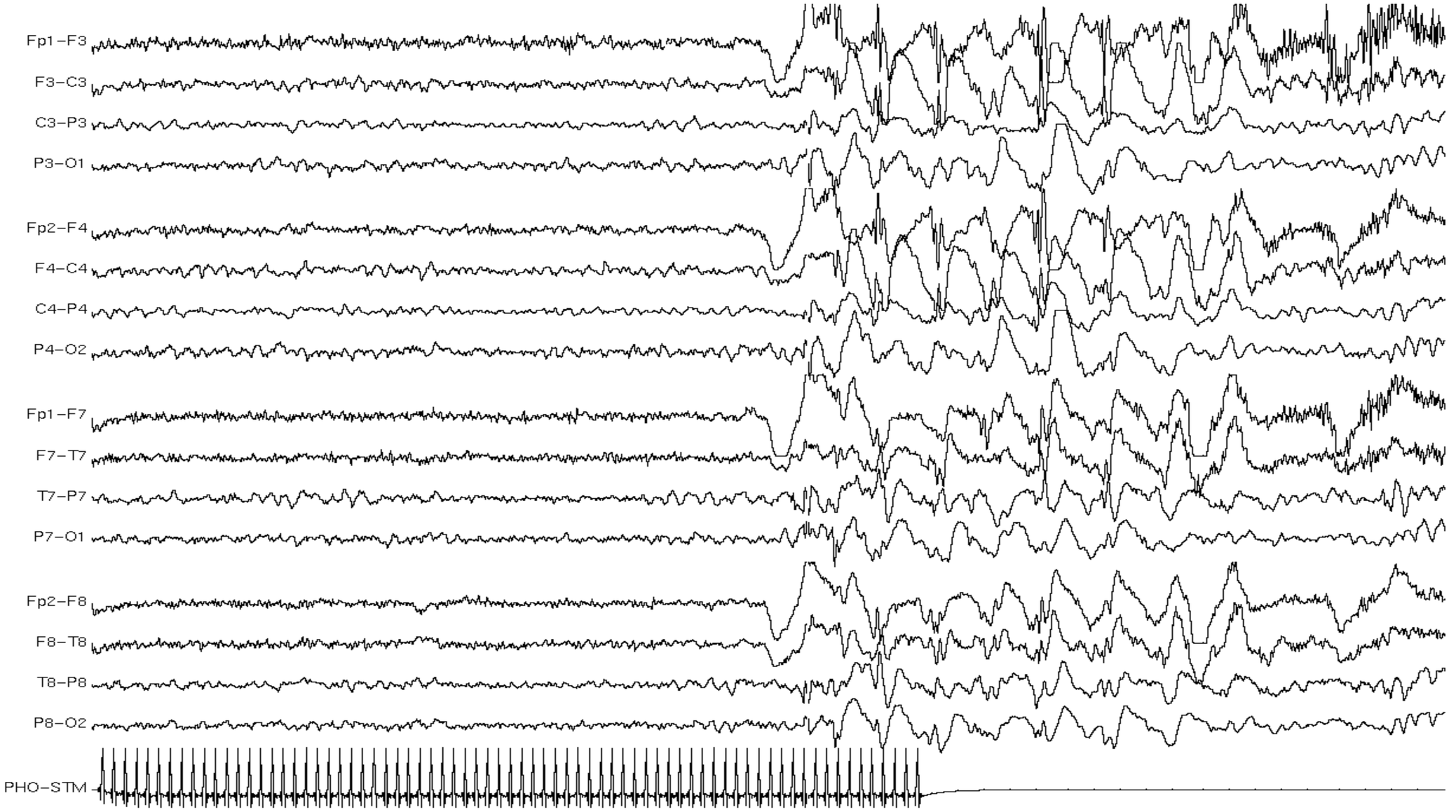


Photo-epileptiform discharges (Photo paroxysmal response)

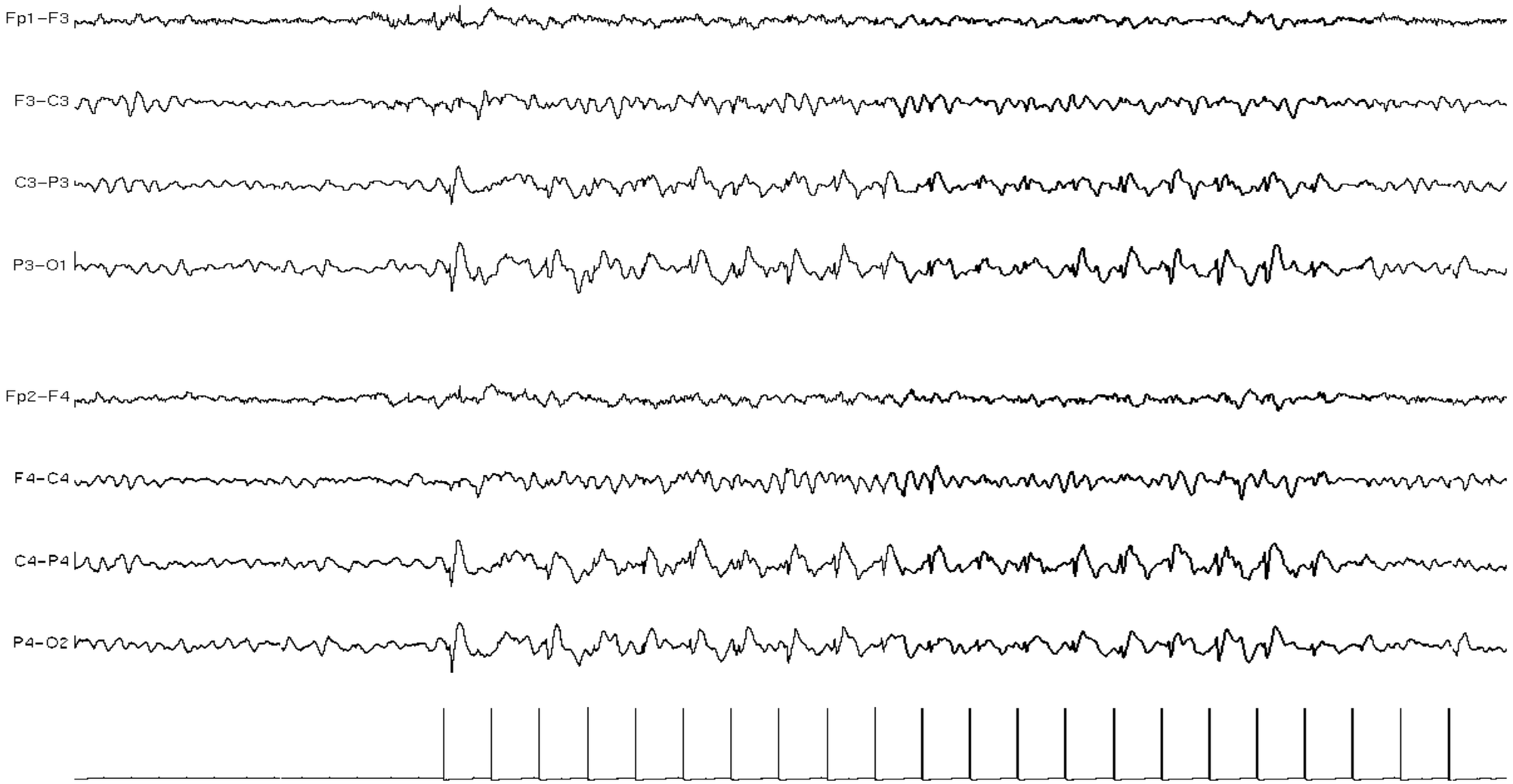
- IEDs elicited by intermittent photic stimulation, commonly associated with primary generalized epilepsy
- Can be self-limited (the discharges do not exceed the stimulation) or self-sustaining (the discharges outlast the stimulation)
- Four categories
  - (1) Generalized (most common)
  - (2) Bilateral posterior dominant
  - (3) Bilateral occipital
  - (4) Focal unilateral (least common)
- 77% of generalized photo-epileptiform discharges have seizure disorder, except bilateral occipital photo-epileptiform discharges are less commonly associated with epilepsy

Halasz P., et al. Degen R, Rodin E, eds. Epilepsy, sleep and sleep deprivation. Amsterdam, the Netherlands: Elsevier Science Publishers B.V., 1991:49–71.

Generalized photo-epileptiform discharges



Bilateral posterior dominant photo-epileptiform discharges



Take Home Message

IEDs help in diagnosis of epilepsy/epileptic syndrome, but not absolute and frequency of IEDs may not associated with severity

Try to identify
focal VS generalized
Need to correlated with clinical history

Practice makes perfect!!

THANK YOU

Email : natrujee.w@gmail.com