

EEG Artifacts

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Nov. 2016

The perfect EEG

- **A “perfect” EEG:** contains only signals from the cerebral cortex
- **Reality:** EEG contains signals from the cerebral cortex... many other objects near the patient that generate an electrical field

EEG artifacts

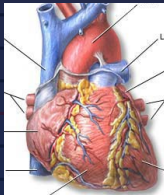
- Scalp EEGs record tiny (microvolt) signals
- Electrodes detect electrical “noise” from many other sources
- Artifacts can completely obscure underlying EEG
- Artifacts can also mimic or distort normal EEG brain activity, leading to misinterpretations

Artifacts and Noise in the ICU

Movement



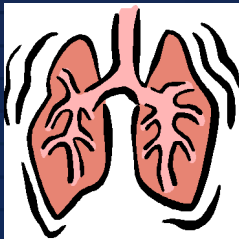
Cardiac



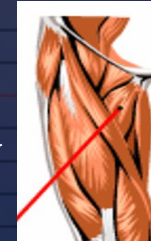
Electrodes



Ventilator



Muscle



Eyes



Telephone



Catheters, external devices

ICU EEG

Why ICU EEGs have more artifacts (and harder to detect artifacts) than regular EEGs:

- Electrodes
- Electronics
- Equipment
- Staff and patient movement
- Abnormal physiology

Electrode integrity in the ICU

- ICU EEGs are often prolonged
 - May have worse electrode integrity over time
 - Frequent electrode replacement may → skin breakdown
- ICU patients may have head wounds / injuries that → worse electrode integrity. Ex:
 - Scalp hematoma from head trauma
 - Drainage from craniotomy site
- If not using CT / MRI compatible electrodes, may → frequent disconnection for imaging studies
 - 54% of patients are imaged during cEEG

ICUs and personnel

Intensive care unit (ICU) rooms are busy places

- High nurse-to-patient ratio
- Hourly vital signs, neuro checks
- Large multidisciplinary ICU teams
- Patients are touched on average 103x / 24h
- People enter and leave room frequently

Frequent movement, assessment can → movement of EEG equipment, electrodes, cables, cameras → additional artifacts

ICU EEG: electronic factors

Multiple electronic devices → monitor ICU patients

- Motorized bed
- EKG / telemetry
- Blood pressure cuff
- Pulse oximeter
- Swan-Ganz catheter
- Pacemakers
- Left ventricular assist device
- Extracorporeal membrane oxygenation
- Incubator (in neonatal ICUs)
- Continuous veno-venous hemofiltration devices
- Fans
- Licox tissue oximetry monitor
- Intracranial pressure monitor
- Cooling / warming blankets
- Ventilator
- IV fluid machines

MOST OF THESE DEVICES CAN POTENTIALLY CREATE ARTIFACTS

ICUs have active patients

Many patients in the ICU are prone to abnormal movements due to their underlying condition:

- Tremor
- Clonus
- Rigors
- Postanesthetic shivering
- Myoclonus
- Asterixis
- Posturing

One study of delirious ICU pts found that 54.9% had episodic hypermotor activity!

ICU physiology

In the ICU, physiologic artifacts are often less recognizable due to physiologic abnormalities

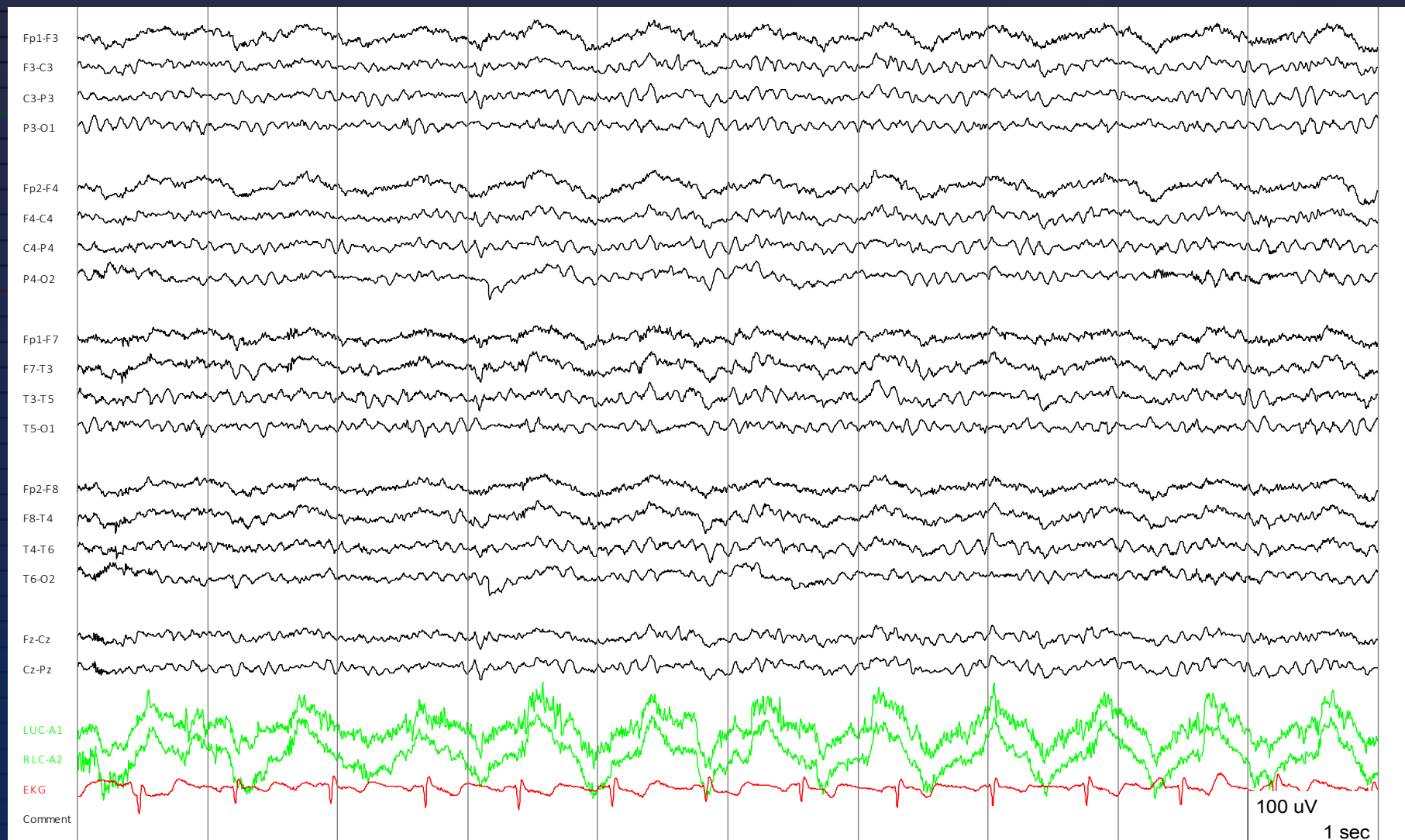
- Eye movement artifact due to nystagmus
- EKG artifact in the setting of cardiac arrhythmia
- Respirator artifact with tachypnea

Artifacts in the ICU

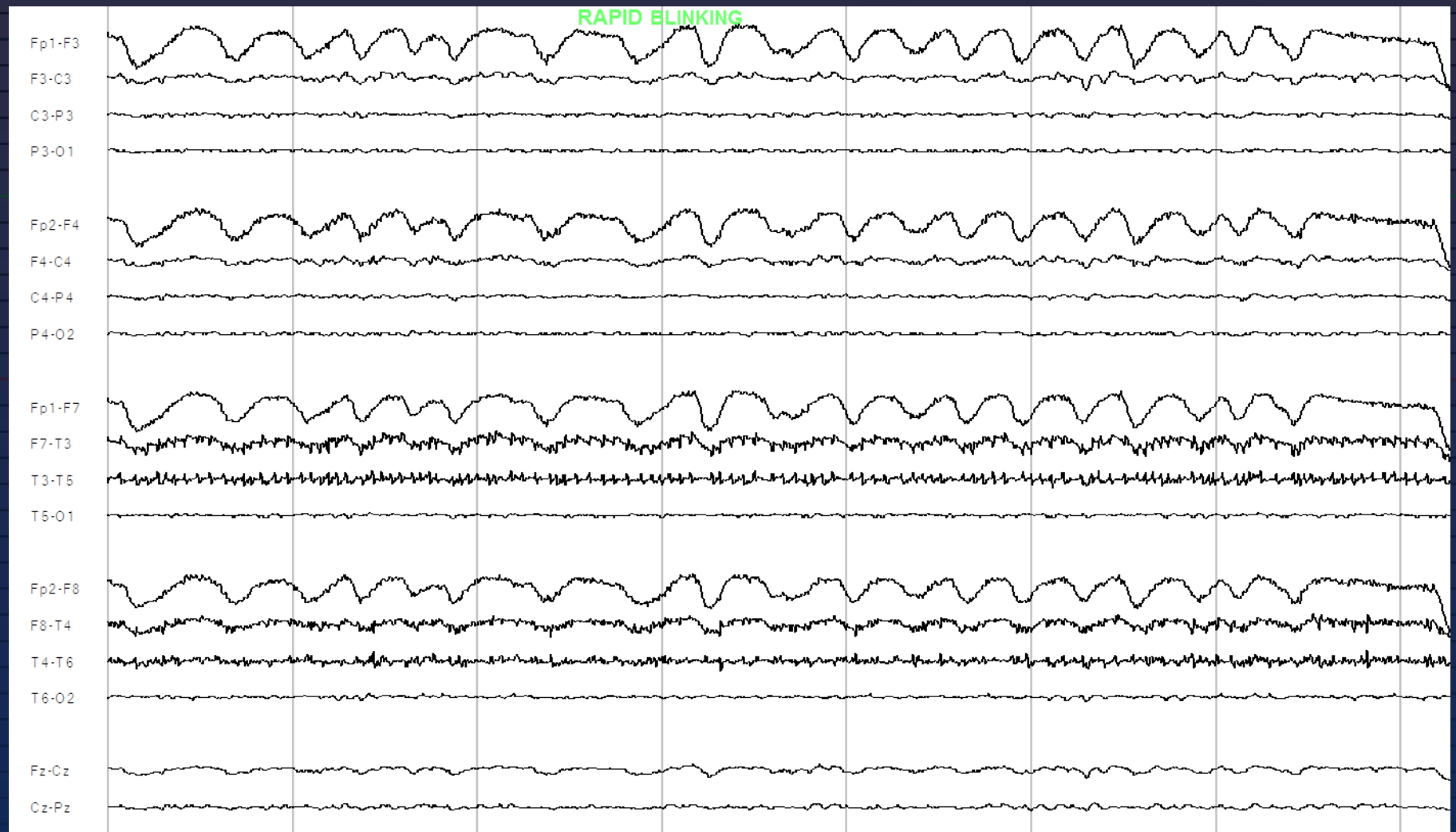
- Physiologic
- Instrument and electrode artifacts
- External mechanical / device related
- Movement

Physiologic artifacts

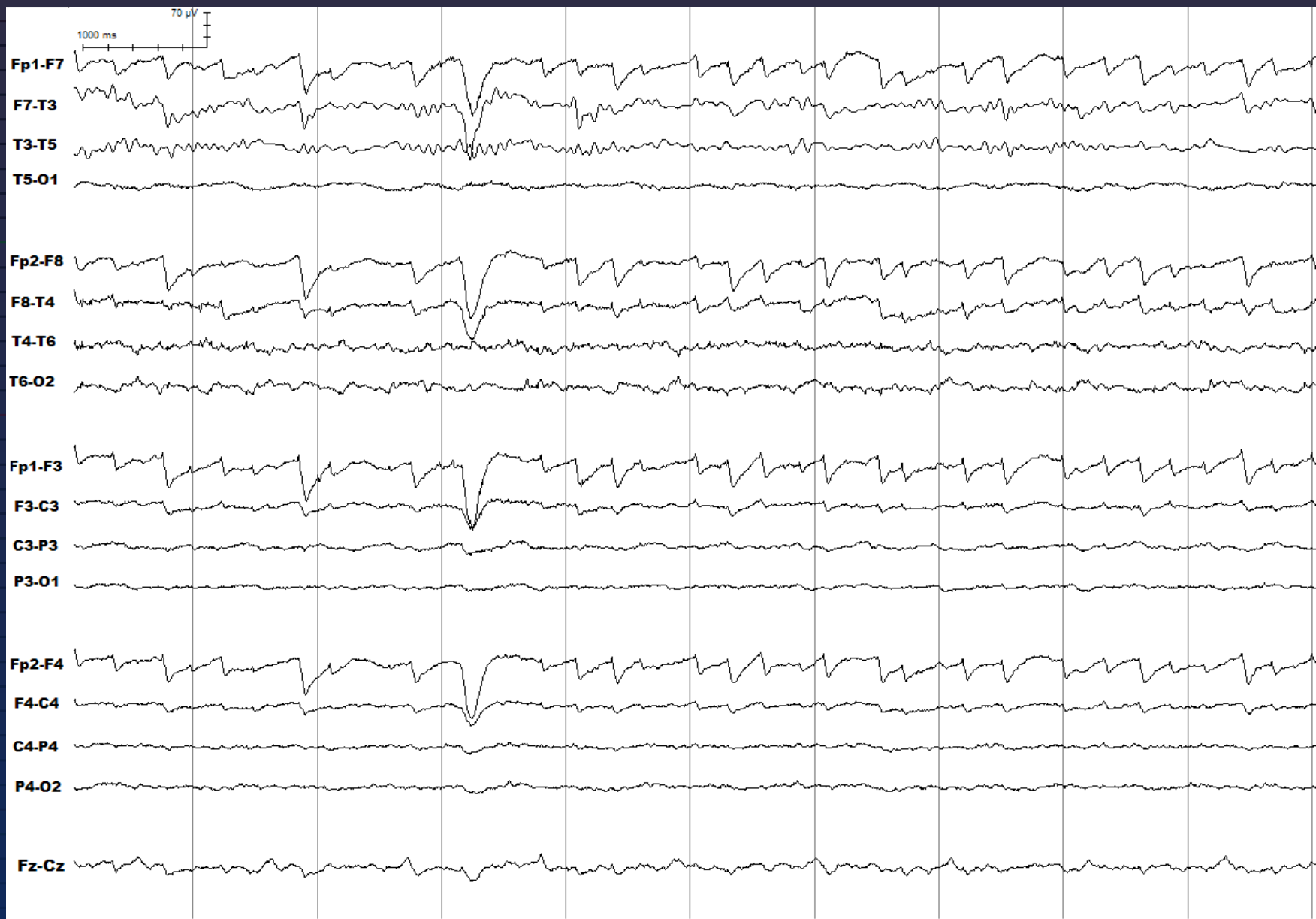
- Eye / ocular artifacts
 - Blink artifact
 - Eye flutter
 - Eye movements / lateral rectus spikes
 - Nystagmus
 - ERG
- EKG artifact
 - Pulse artifact
 - Ballistocardiographic artifact
 - PVC / arrhythmia artifact
 - Pacemaker artifact
- EMG artifact
 - Swallowing
 - Chewing
 - Bruxism
- Glossokinetic artifact
- Respiratory artifact
- Galvanic skin response / sweat artifact



Respiratory artifact is magnified in tachypneic pt



Because many pts in the ICU do not have eye leads placed, nystagmus or abnormal eye movements can be confused for rhythmic delta activity

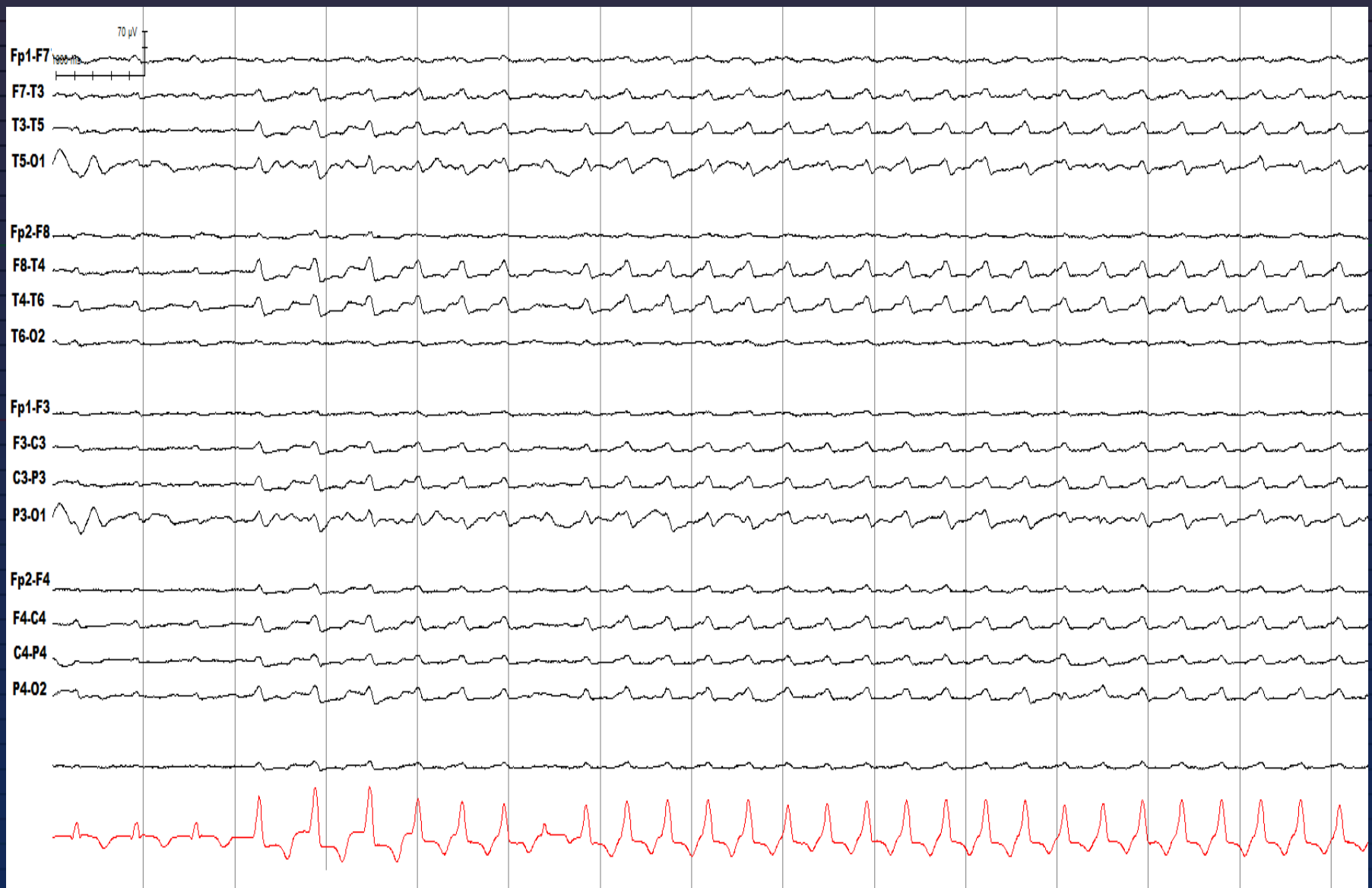


Nystagmus can result from medications, cerebellar or brainstem lesions and can resemble frontal epileptiform activity

Cardiac artifacts

EKG:

- The artifact created by the electrical signals generated by the heart
- Looks like a QRS complex
- More prominent in pts with short, thick necks
- More prominent in montages that use ear as reference
- Irregular cardiac rhythms & widened QRS complexes can resemble epileptiform activity

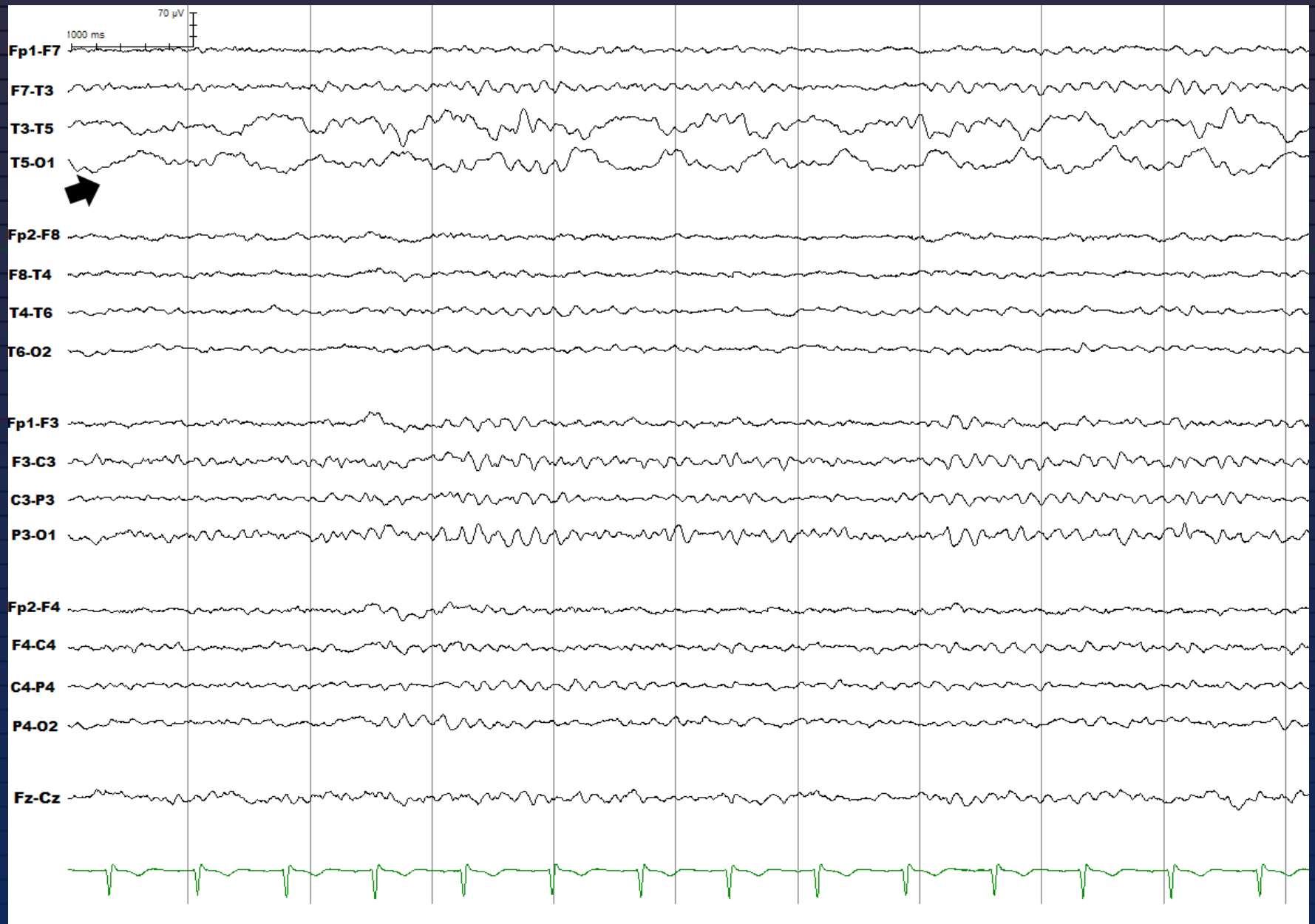


EKG artifact with low voltage background, wide complex irregular tachycardia

All those cardiac artifacts

Pulse:

- The artifact created by placing an electrode over a pulsating artery
- Most common in central, temporal electrodes
- Creates a rounded artifact, time-locked to the EKG
- Irregular heart rate can → arrhythmic delta

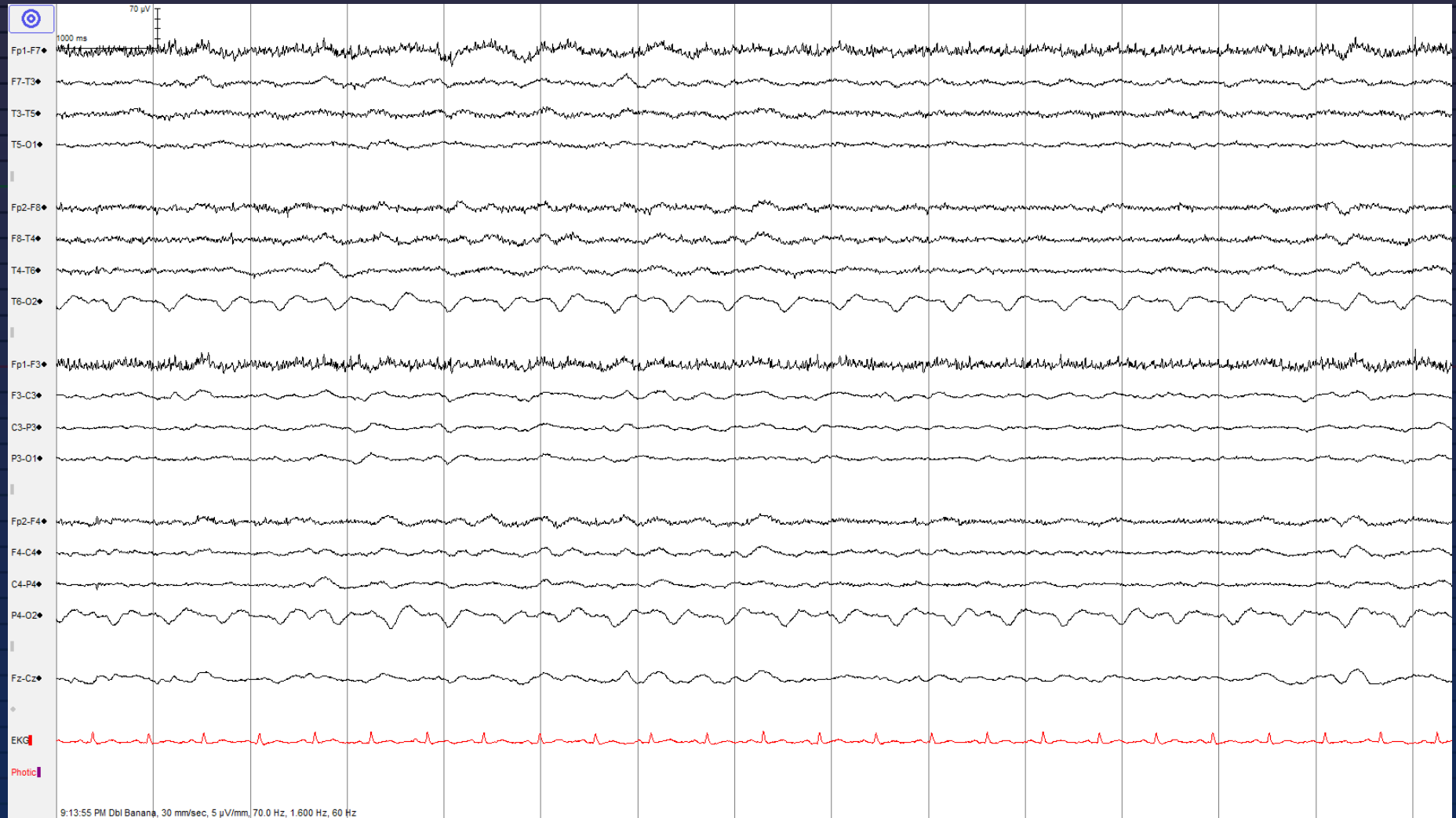


Pulse artifact

All those cardiac artifacts

Ballistocardiographic artifact:

- Looks like pulse artifact: rounded artifact, time-locked to the EKG
- Created by the mechanical movement of the heart → moving the body
- More common in small / thin pts

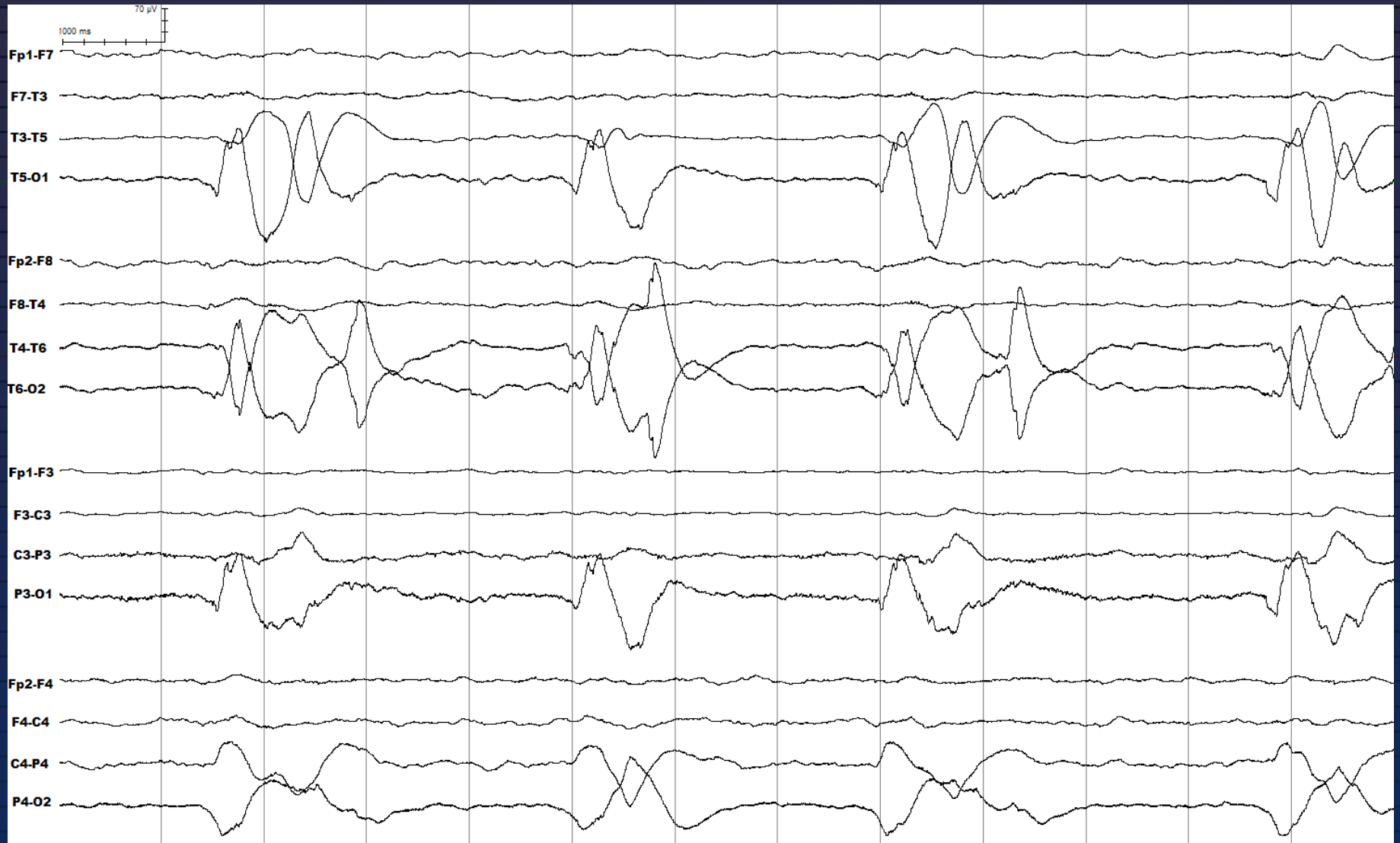


Ballistocardiographic artifact

Ventilator artifacts

Highly variably

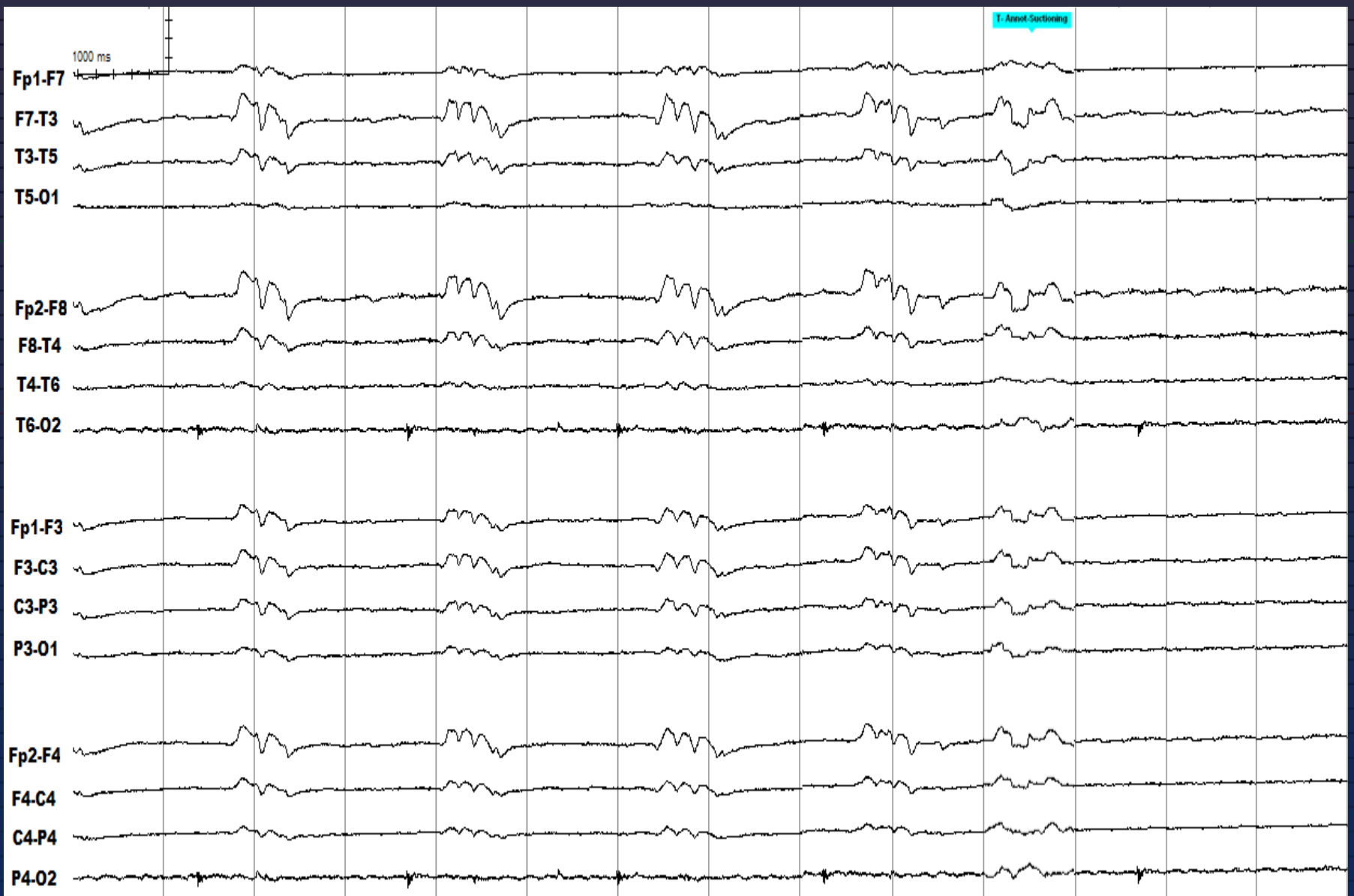
- Can be positive or negative
- Can occur at respiratory rate or at twice the respiratory rate (with inhalation and exhalation)
- May appear slow and rhythmic or sharp
- More common in occipital electrodes (head midline) or temporal / parietal electrodes (head to the side), but can occur anywhere



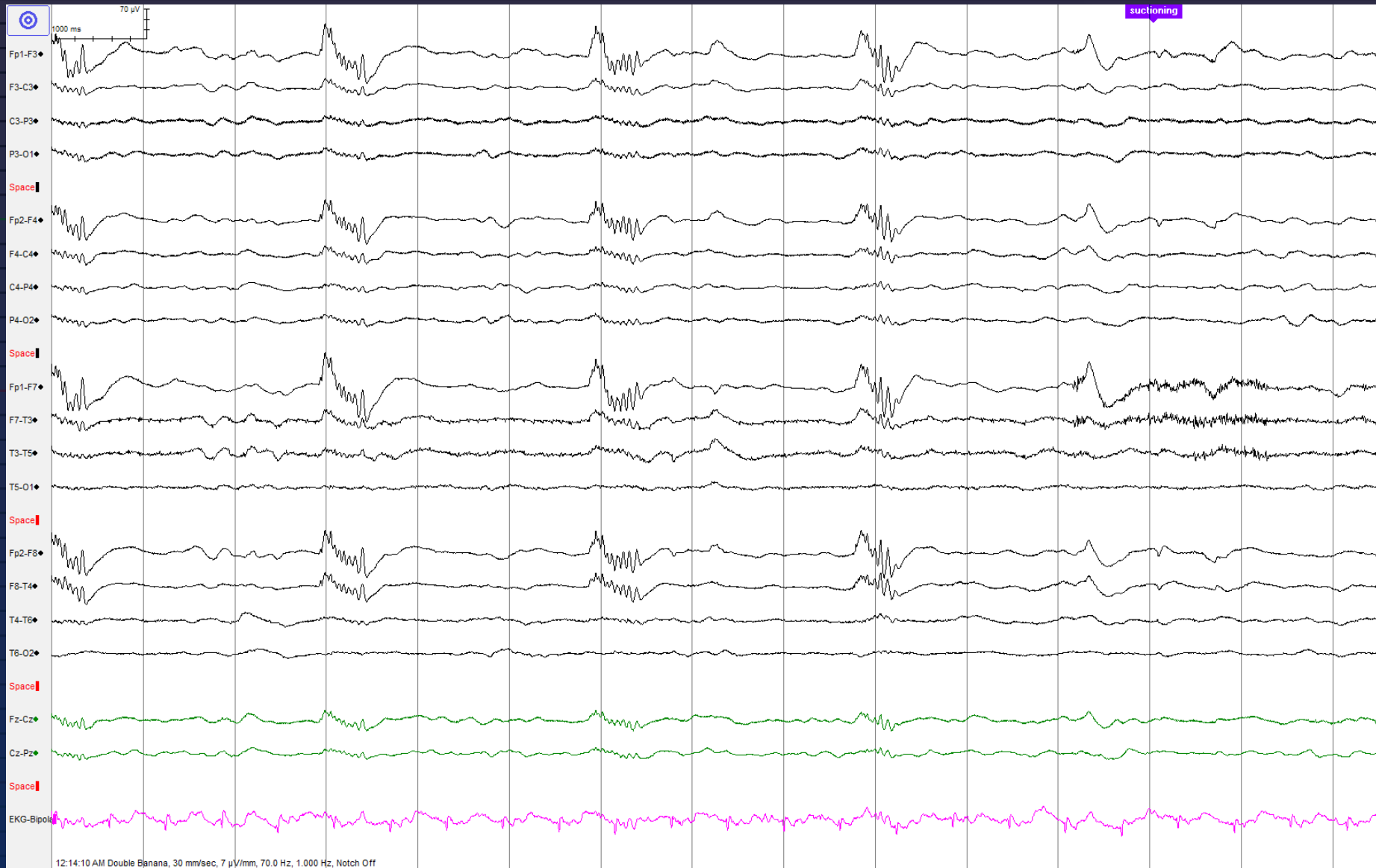
Ventilation artifact

“Water in the ventilator tube”

- A special type of ventilator artifact
- Electrostatically charged water in ventilator tubing rapidly oscillates with each inhalation and exhalation
 - Creates frontally predominant semi-rhythmic alpha, theta or beta activity
 - Often confused with seizure
 - Bursts of alpha-theta get longer and longer as patient accumulates more water in their tube
- Correct by suctioning
- Can also monitor with chin electrode



Water in ventilator tube



Water in ventilator tube

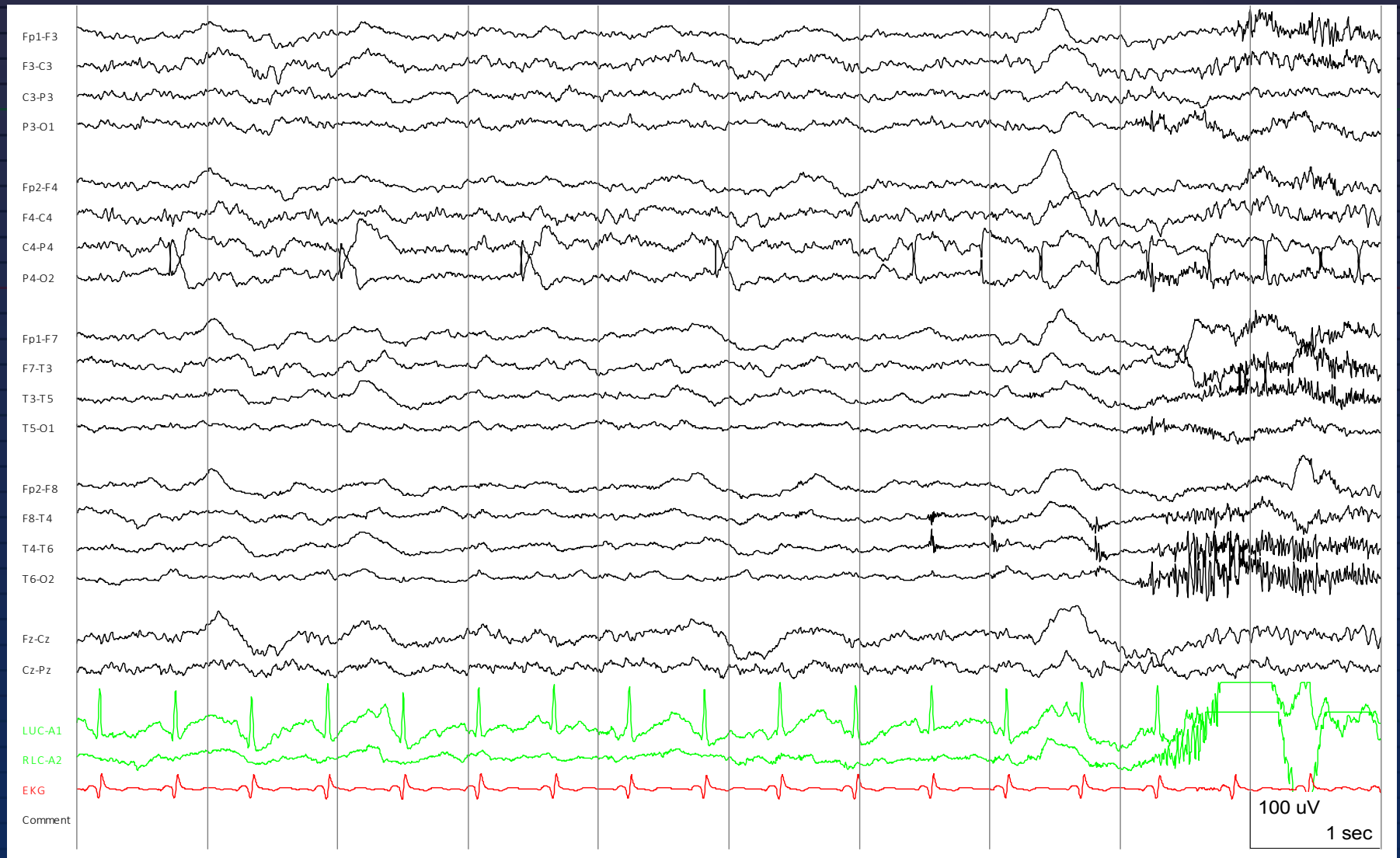
Instrument and electrode artifacts

- **Electrode artifact**
- **60 Hz artifact**
- Amplifier artifact
- Capacitative artifact
- Inductive artifact
- Electrostatic artifact
- Aliasing artifact

Electrode artifact

- More problems with electrode artifact in the ICU
 - Prolonged monitoring
 - Scalp integrity
- Result = electrode artifacts
- Keep electrode impedance $< 10 \text{ k}\Omega$ —many pts require repair 2-3 x / day

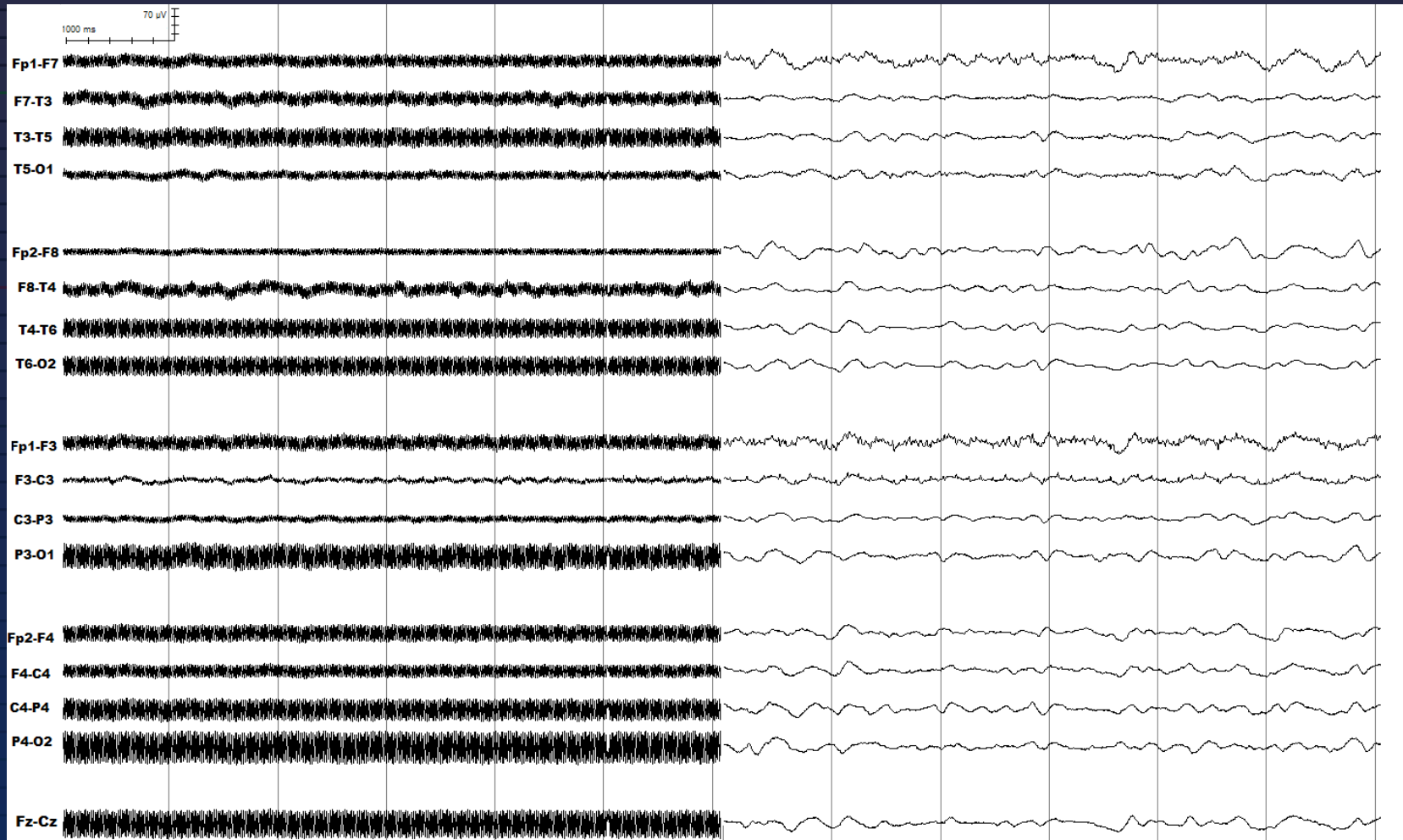
Bad electrode: P4 artifact



60 Hz artifact

- Caused by detection of signals from 60 Hz electrical appliances near patient
- Big problem in the ICU
 - Electrode integrity
 - Many immobile devices surrounding pt
- When possible, move devices away from head
- Use 60 Hz notch filter

60 Hz before and after



This shows a sample ICU EEG recording before (left) and after (right) use of the 60 Hz notch filter

External devices

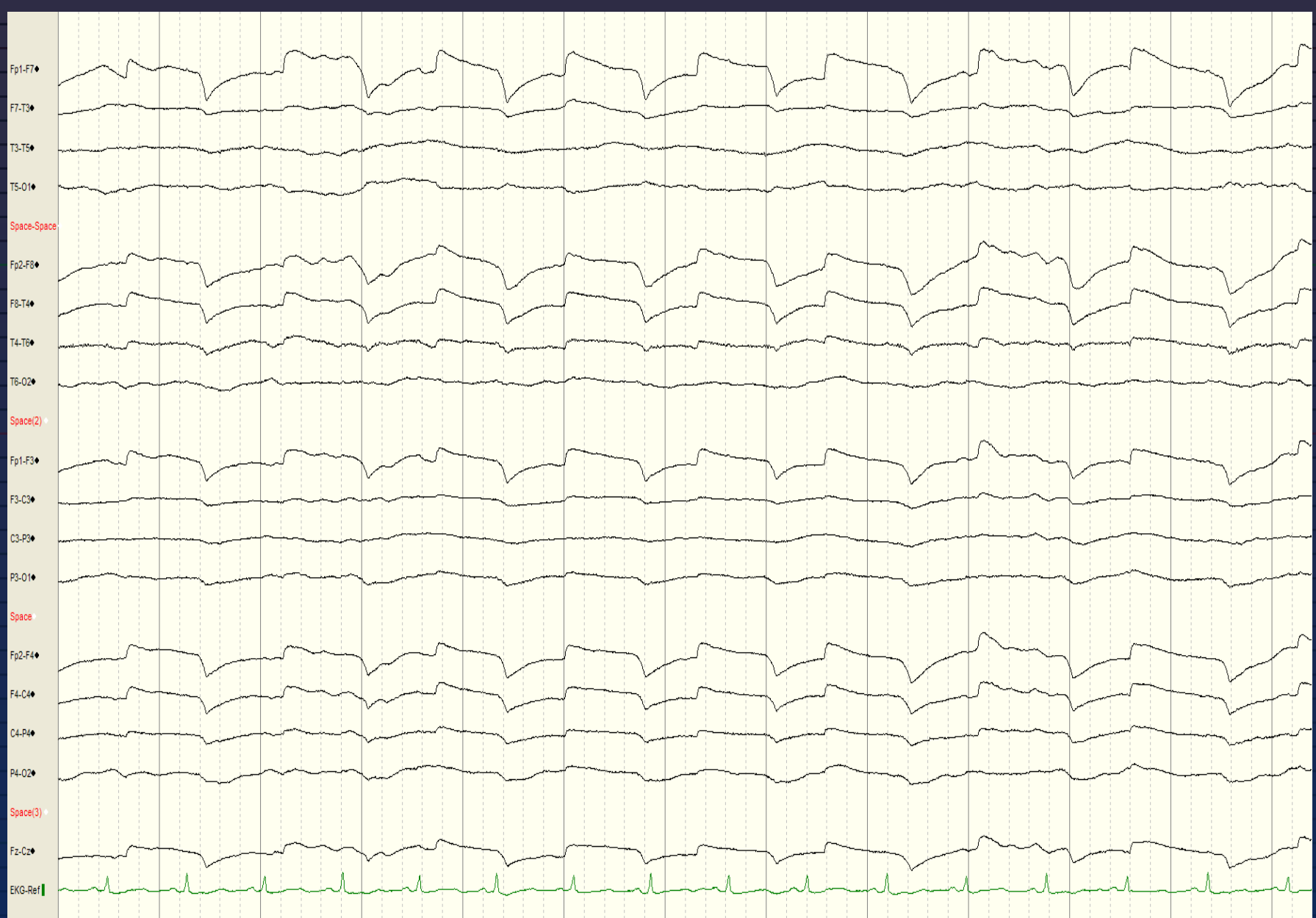
- Almost any device can produce an artifact (usually 60 Hz)
- Particularly common device artifacts:
 - Chest percussion devices
 - Continuous veno-venous hemofiltration
 - Extracorporeal membrane oxygenation

Bed percussion

- Creates 5-6 Hz rhythmic theta activity
- Because it can “spread” to adjacent electrodes if patient moves, it can appear to “evolve”



Bed percussion

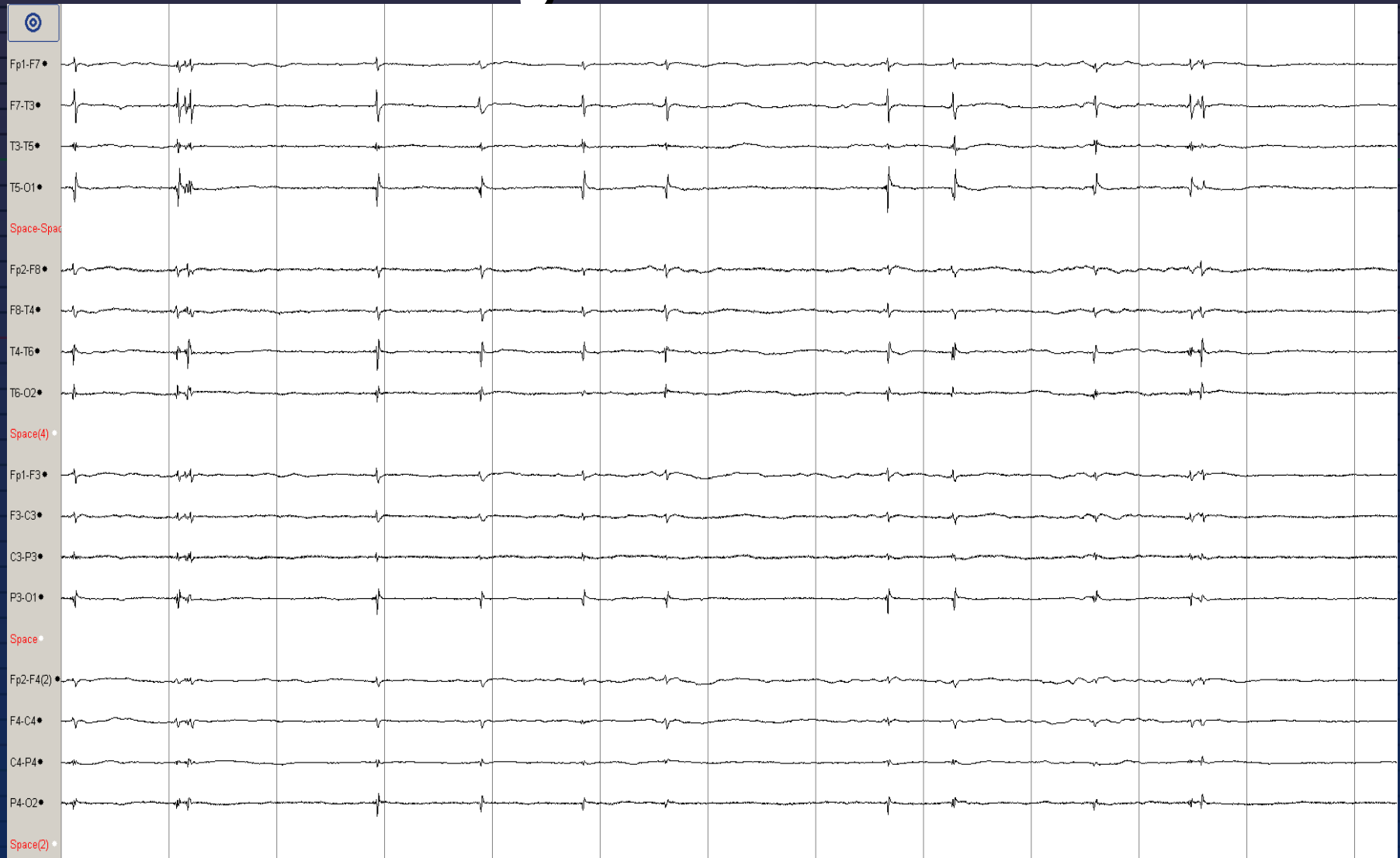


Extracorporeal membrane oxygenation (ECMO) artifact (seen here) can usually be minimized by moving the pump away from the patient's head

Movement

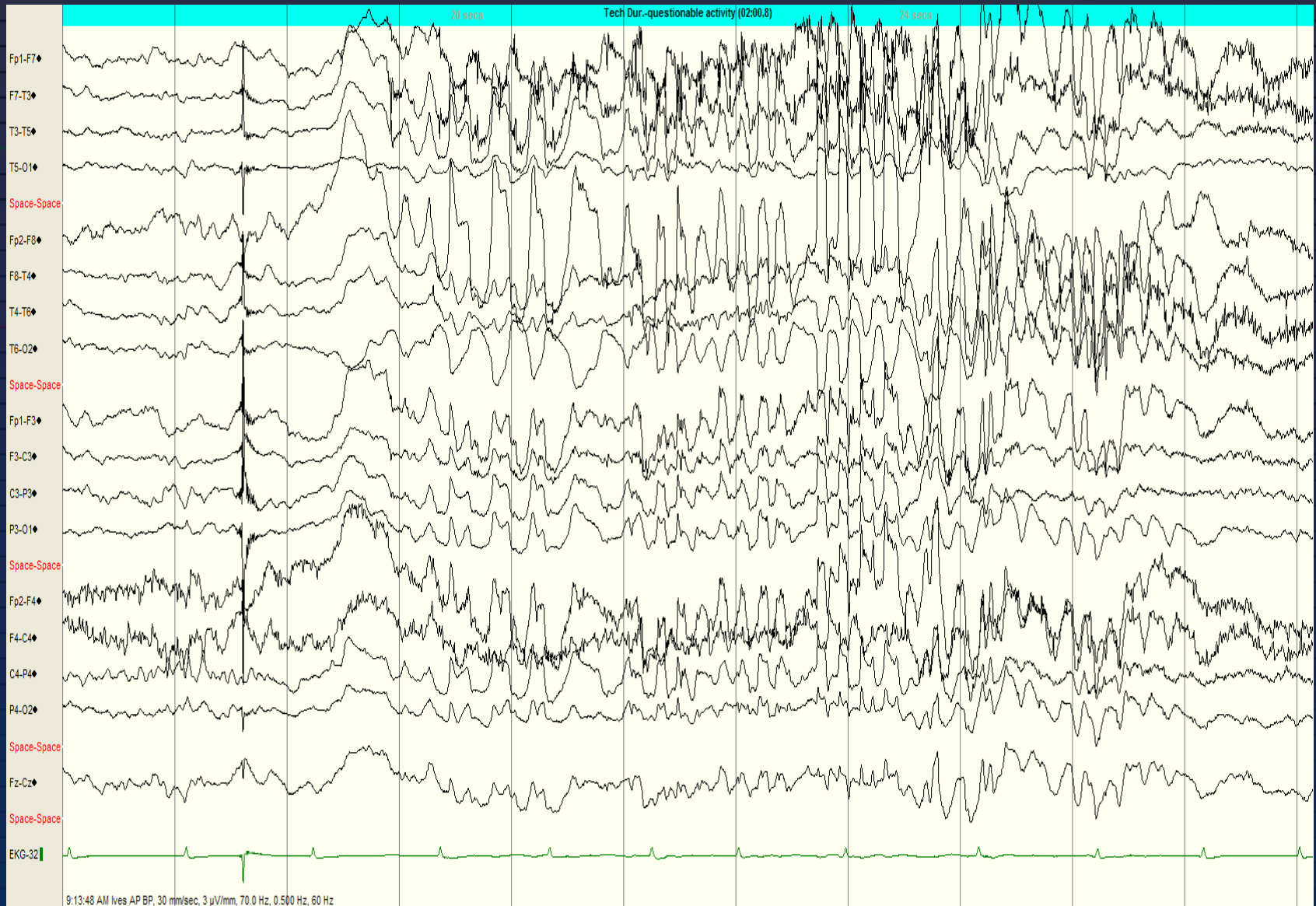
- Many movements can create artifacts, sometimes rhythmic
- Video is imperative
- Patient movements
 - Myoclonus
 - Clonus
- Staff movements
 - Sternal rub
 - Suctioning

Myoclonus



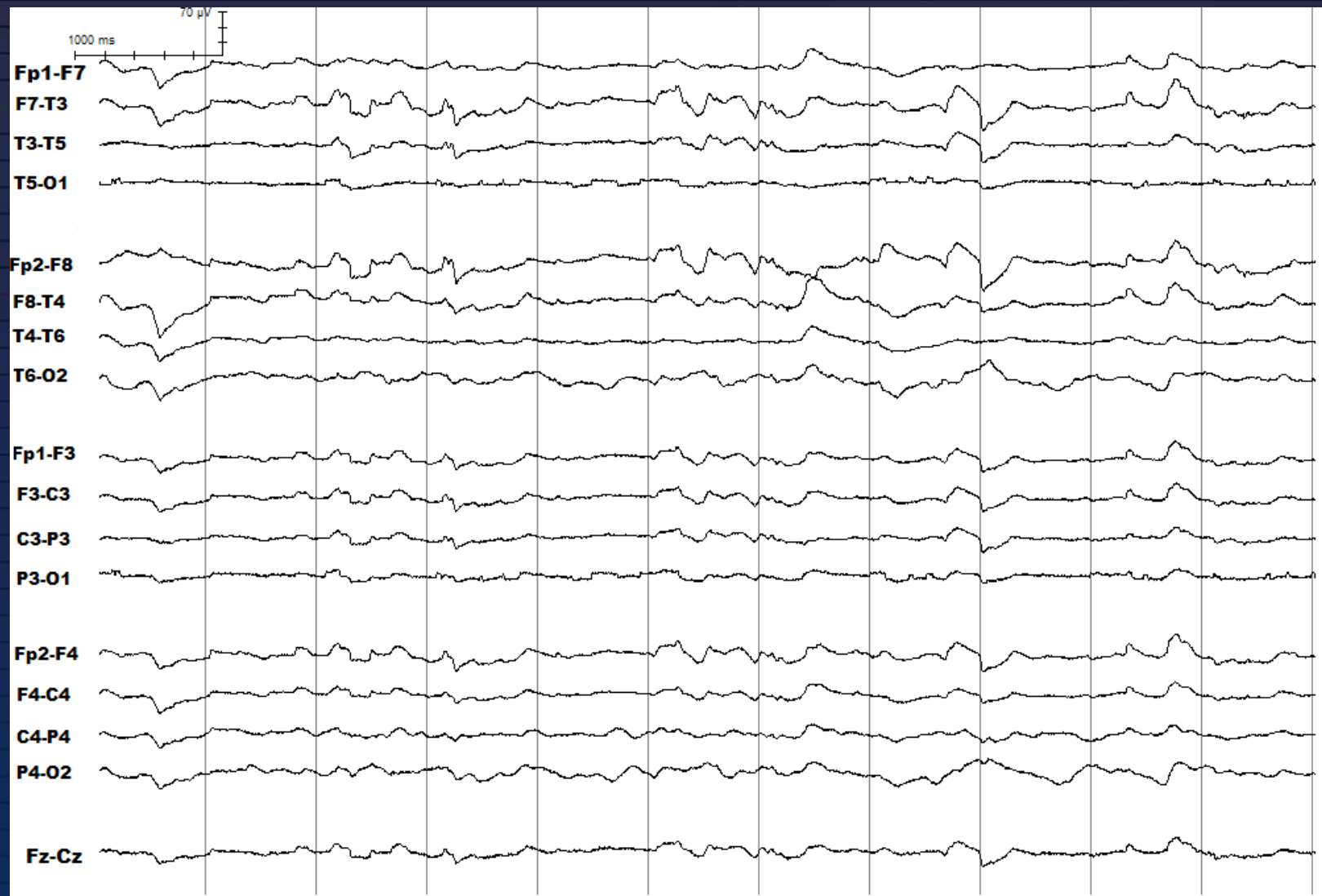
Spiky, nonphysiologic phase reversals, easy to confuse with epileptic spikes

Sternal rub



Can look rhythmic or evolving but usually irregular with strange field: correlate with video!

Suctioning



Creates irregular theta and delta activity, at times semi-rhythmic

Conclusions

- The ICU is filled with sources of artifacts!
- Although steps can be taken to minimize artifacts, some artifacts are inevitable
- Recognize the appearance of common artifacts, look at patient videos and document patient activities to avoid mistakes