Scoring Sleep Stages: N1

Sleep Onset

- Defining sleep onset often presents some challenges. There are electrophysiological changes such as the disappearance of alpha rhythm that mark sleep onset in many individuals. 10-20% of the population, however, generate little or no alpha rhythm. Thus, factors other than EEG changes must be used to determine sleep onset in these individuals. Several changes occur at the wake-sleep boundary which have been evaluated by investigators. These include changes in eye movements and cardiorespiratory parameters, as well as changes in cognitive function which occur with drowsiness and onset of sleep.

Sleep Onset

- Rather than attempting to use the numerous data to define the boundary between wake and sleep, the AASM Manual for the Scoring of Sleep and Associated Events used consensus opinion to determine the factors most important in identifying sleep onset. The definition of sleep onset in alpha generators is defined as the start of the first epoch scored as any stage other than stage W based on disappearance of the posterior dominant (alpha) rhythm. In most subjects, this will usually be the first epoch of stage N1 although in certain conditions, such as infancy and narcolepsy, this may be REM.

Sleep Onset

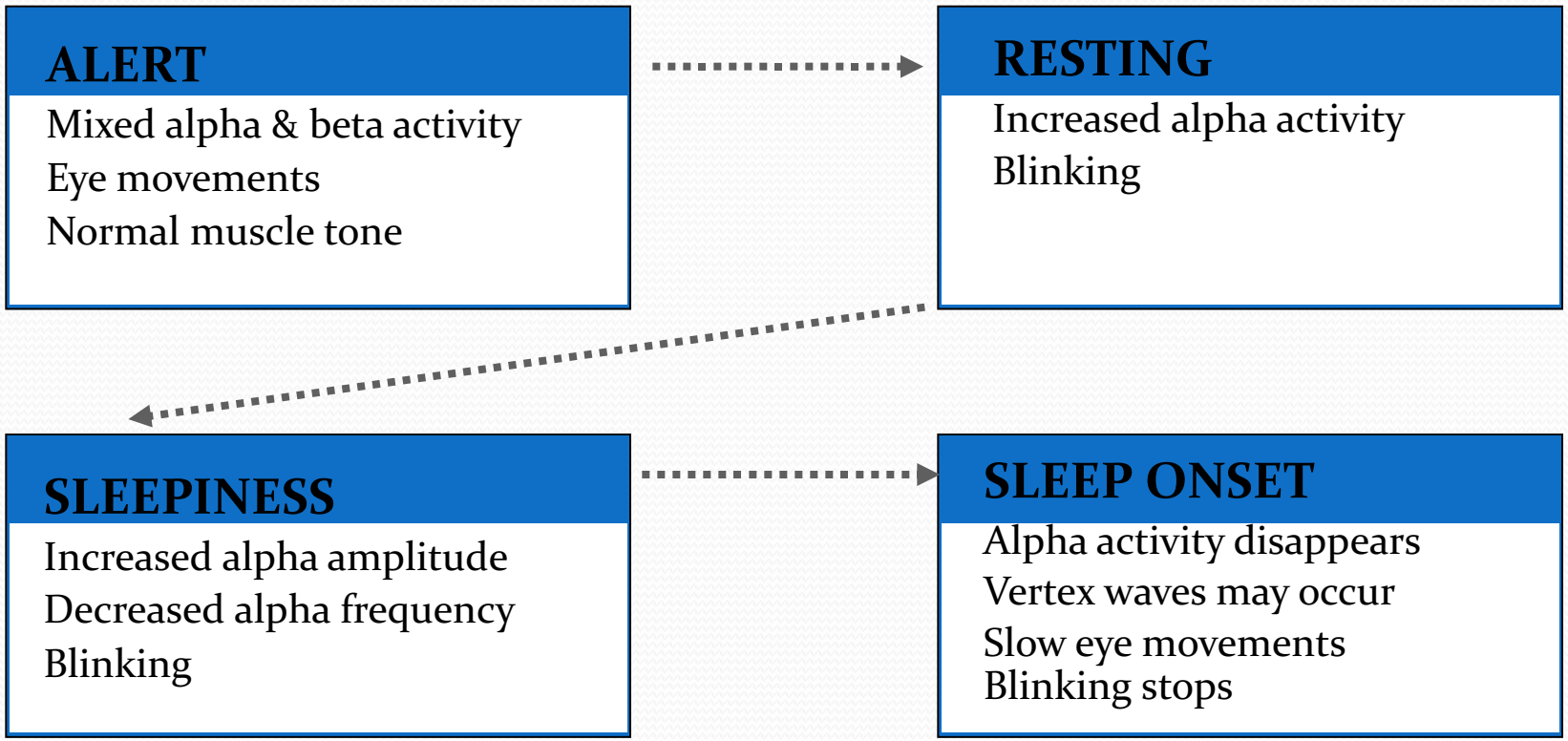
- In individuals who generate little or no posterior dominant (alpha) rhythm, the development of slow eye movements in the EOG is felt to be the best measure of early sleep. Other changes, such as vertex sharp waves and slowing of the background EEG, can also help identify sleep onset.

- Sleep onset is defined as the first epoch of sleep.

Sleep Onset Summary

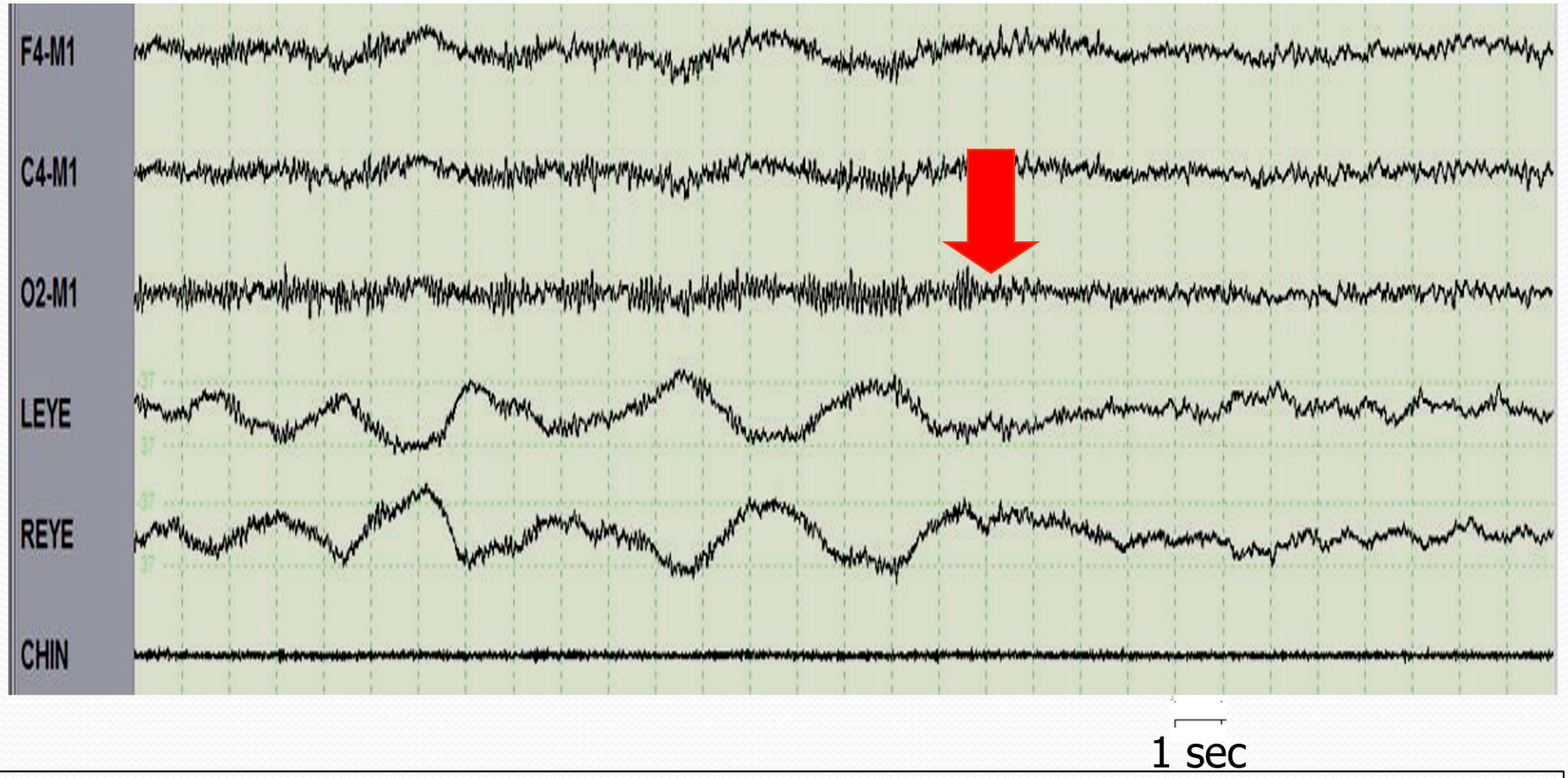
1. Transition from wakefulness to sleep (usually stage N1)
2. Usually marked by posterior dominant (alpha) rhythm disappearance
3. Appearance of slow eye movements

Physiological Correlates of Progressive Sleepiness



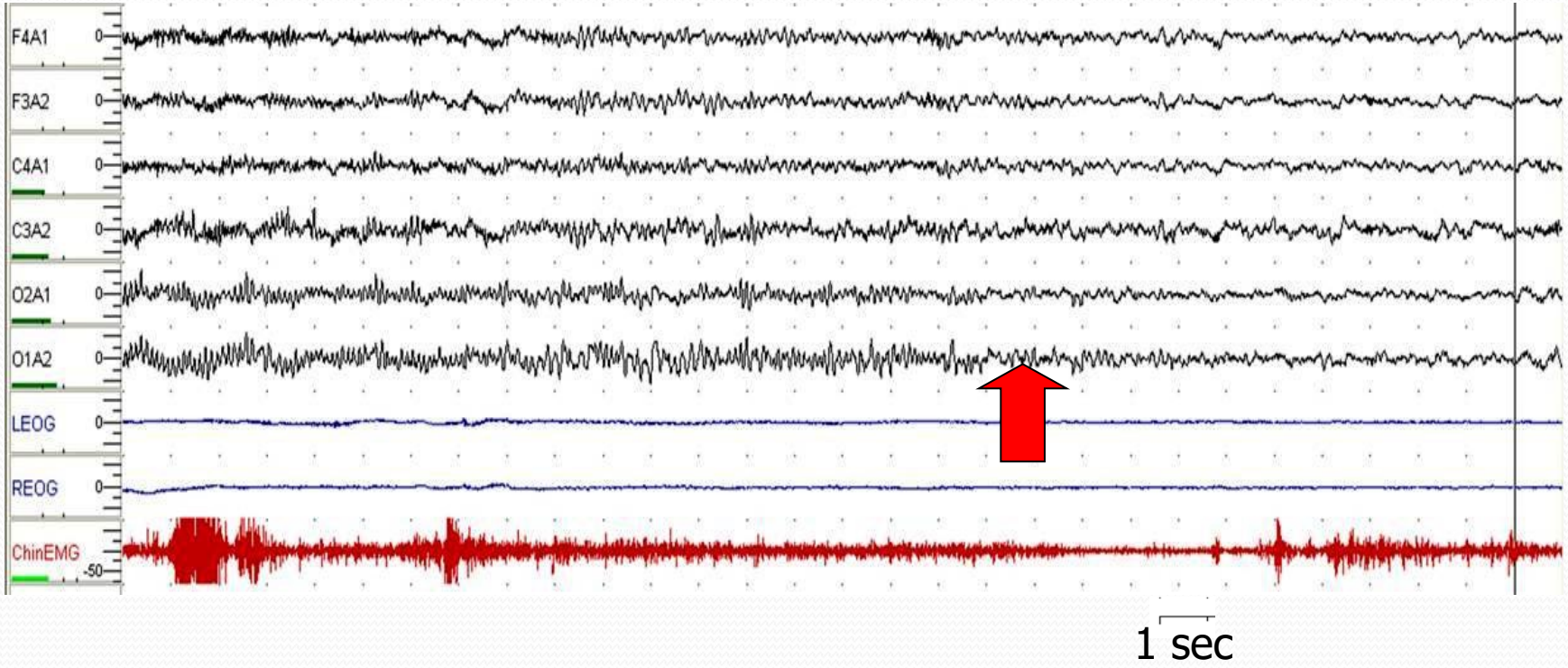
This slide shows the normal polysomnographic correlates associated with progression from alertness to sleep onset. Beta activity is defined as a wave or sequence of waves with a frequency greater than 13 Hz. It is the normal predominant rhythm observed while awake and with eyes open.

Sleep Onset



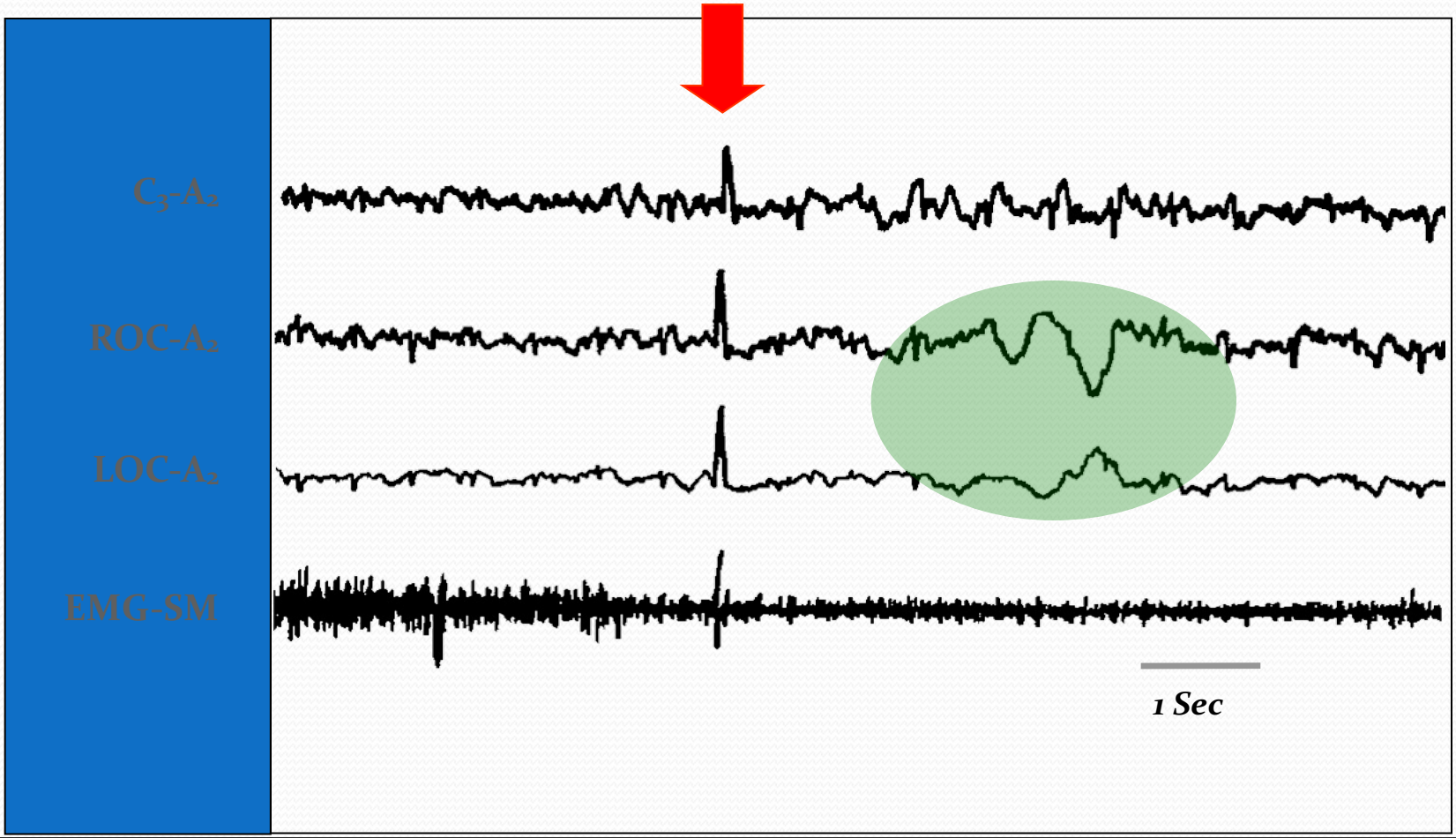
This slide shows a classic example of physiologic sleep onset. Sleep onset (red arrow) is easily recognized by the disappearance of alpha activity, the presence of slow eye movements, and the eventual decrease in submentalis EMG activity. An absence of blinking is also apparent. It is worthwhile to note that the moment of physiologic sleep onset is <u>not</u> necessarily the same as the first epoch scored as sleep.

Sleep Onset Without Slow Eye Movements (SEMs)



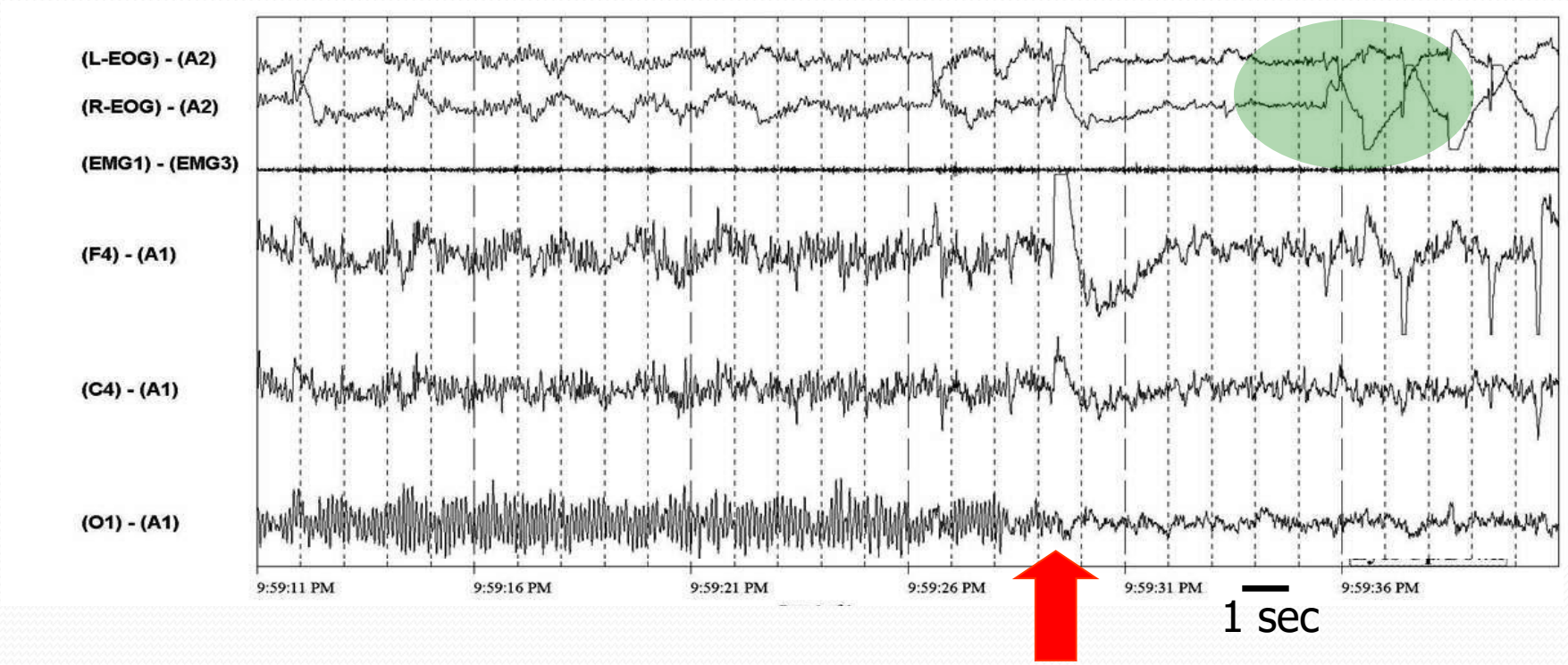
In this example, we also see a clear disappearance of alpha activity and a decline in submentalis EMG. Sleep onset (red arrow) has occurred even though no slow eye movements are present.

Sleep Onset in Non-Alpha Subject



One of the problems with using alpha criteria for assessing sleep onset is when individuals are "non-alpha" types. This shows sleep onset in a normal volunteer who does not have alpha activity. Note the vertex sharp wave (red arrow) and slow eye movements (highlighted in green) associated with EEG slowing during sleep onset, as well as the declining submentalis EMG.

Alpha Blocking by Eye Opening

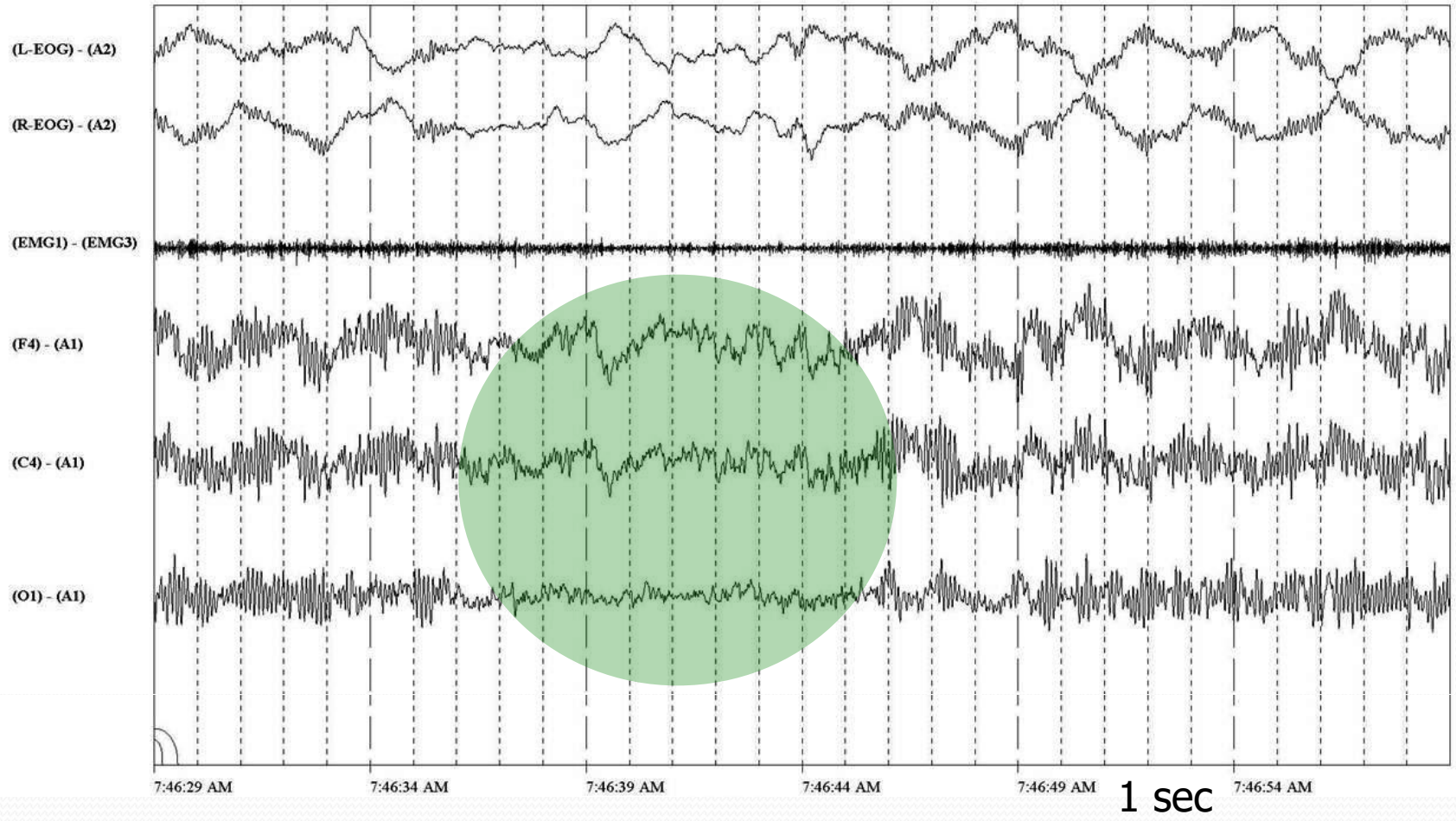


This slide shows the disappearance of alpha activity that occurs when an individual opens his/her eyes. This "alpha blocking" should not be confused with the moment of sleep onset. Eye movement and blinking (green highlight) can be seen after the alpha activity ceases (red arrow), indicating that sleep onset has not occurred.

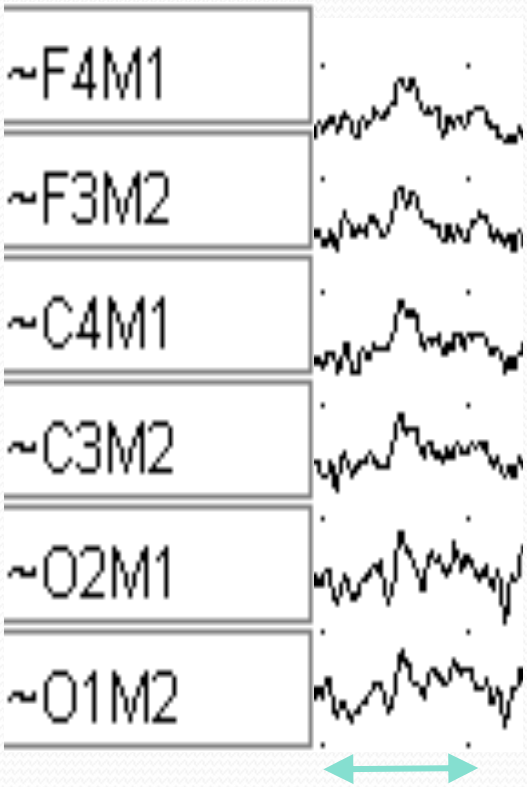
Microsleep

- A microsleep is a sleep episode that lasts for approximately three to 15 seconds. During this brief sleep episode, responsiveness to the environment is absent or impaired. Microsleeps can occur with eyes open or closed and usually occur without warning. When a sleep episode exceeds 15 seconds (using the typical 30-second recording epoch), it is scored as a sleep stage.
- Microsleeps, because they occur for only a few seconds, are not represented in the epoch-based sleep stage scoring system. The length of a football field would have been traveled if this six to seven second microsleep shown in the next slide (highlighted in green) had occurred while driving at highway speed (60 miles per hour).

Microsleep


(L-EOG) - (A2)
(R-EOG) - (A2)
(EMG1) - (EMG3)
(F4) - (A1)
(C4) - (A1)
(O1) - (A1)
7:46:29 AM
7:46:34 AM
7:46:39 AM
7:46:44 AM
7:46:49 AM
7:46:54 AM
1 sec

Vertex Sharp Waves

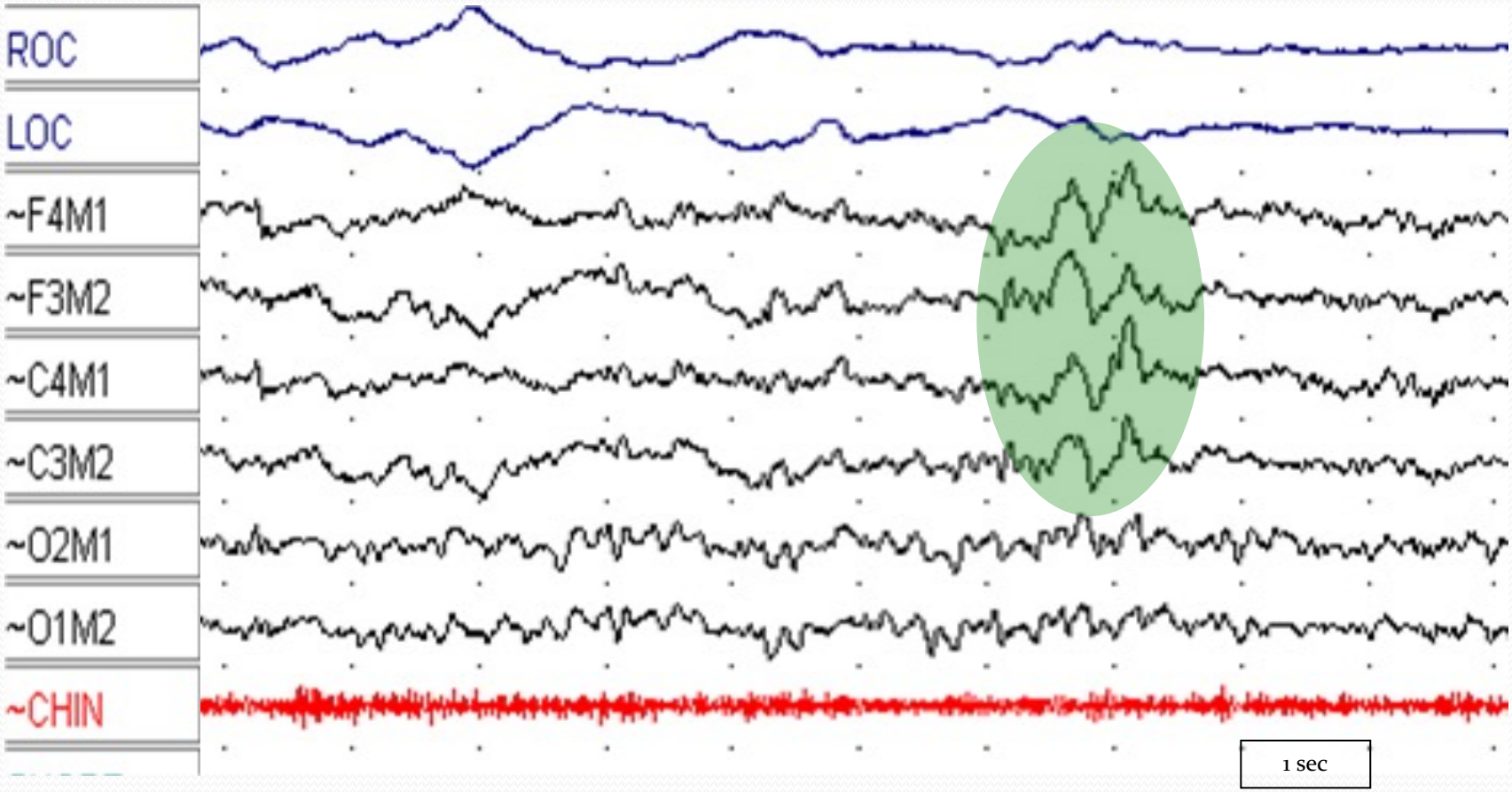


1 second

Sharply contoured waves with duration < 0.5 seconds maximal over the central region and distinguishable from the background activity.

Vertex sharp waves (V waves), first and foremost, must be distinguishable from the background – they must "pop out" at you. There is no amplitude criterion for vertex sharp waves. There are duration and source criteria: vertex sharp waves must last less than 0.5 seconds and arise from the central region. Vertex sharp waves are common during N1 and can be seen during N2. They are rarely seen in other sleep stages.

Vertex Sharp Waves



The vertex sharp wave is a sharp potential, maximal at the vertex, negative relative to other areas, occurring apparently spontaneously during sleep or in response to sensory stimuli during sleep or wakefulness. It may be single or repetitive. Amplitude varies but rarely exceeds 250 microvolts. To accurately identify vertex sharp waves, appropriate electrode placement and chart speed is required. Two vertex sharp waves are highlighted in green on this slide.

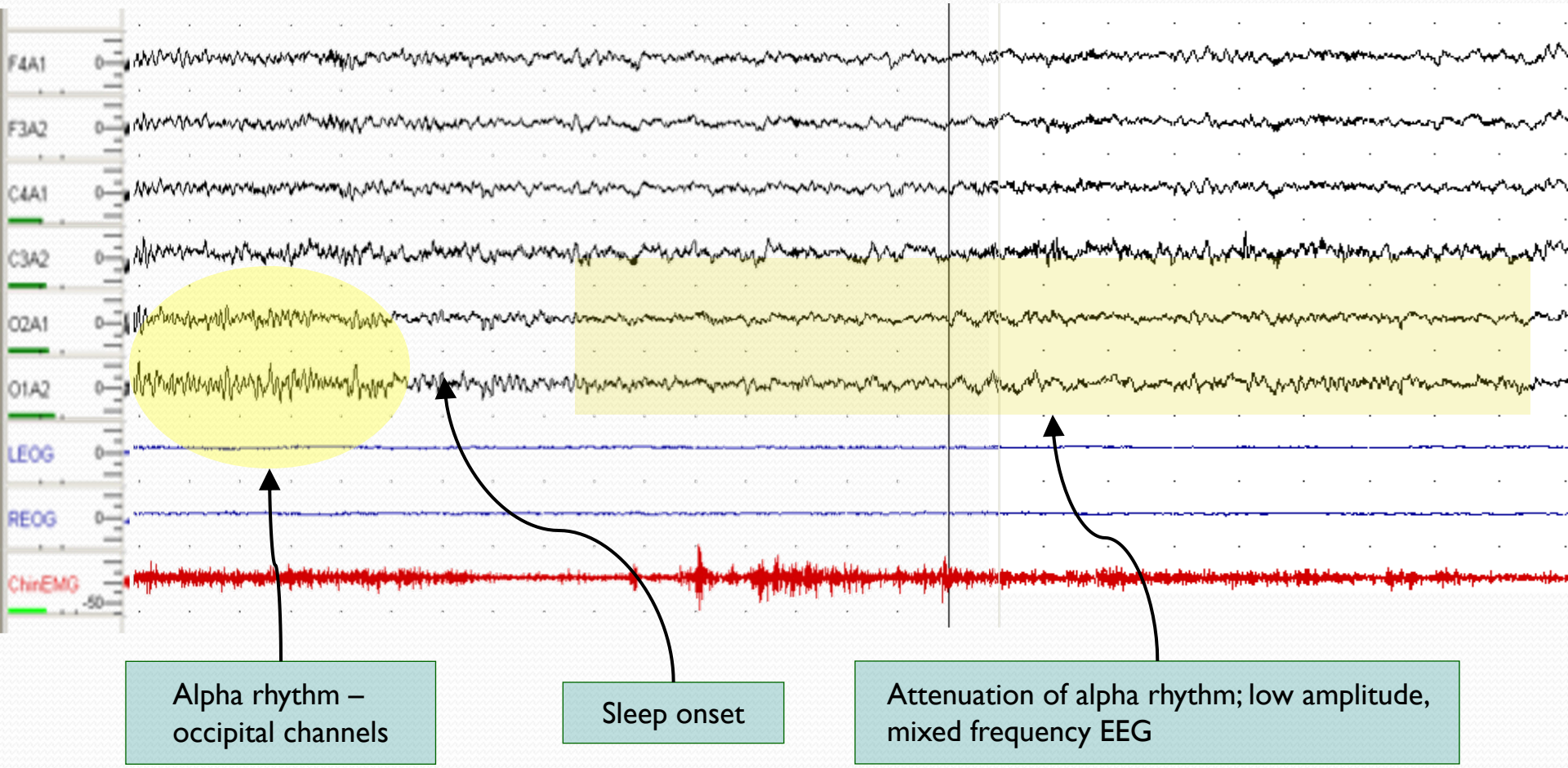
Stage N1 Definitions

- Slow eye movements (SEM): Conjugate, reasonably regular, sinusoidal eye movements with an initial deflection that usually last >500 msec
- Low-amplitude, mixed-frequency (LAMF): Low-amplitude EEG activity that is predominantly 4-7 Hz
- Vertex sharp waves (V waves): Sharply contoured waves with duration <0.5 seconds, maximal over the central region, and distinguishable from the background activity.

Stage Scoring Rules - N1

A. In subjects who generate posterior dominant (alpha) rhythm, score stage N1 if PDR (alpha) is attenuated and replaced by low amplitude, mixed frequency activity for more than 50% of the epoch.

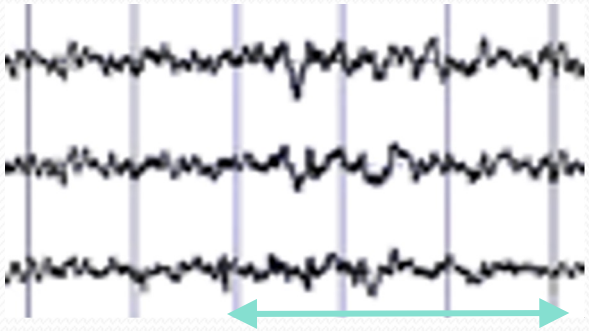
N1 Sleep – Rule A



30 seconds per screen

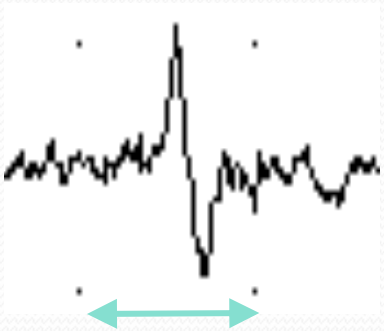
Stage Scoring Rules - N1

B. In subjects who do not generate PDR (alpha), score stage N1 commencing with the earliest of any of the following phenomena:



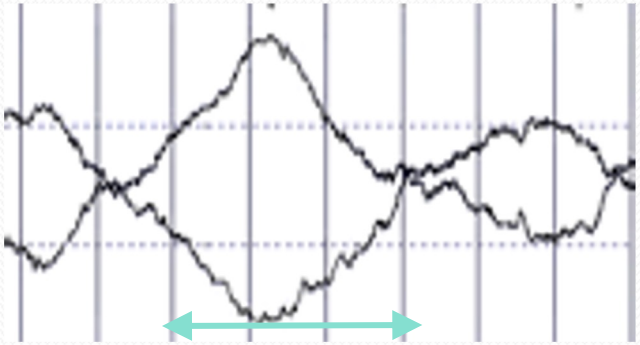
3 seconds

4-7 Hz activity with slowing of background frequencies by ≥ 1 Hz from those of stage W



1 second

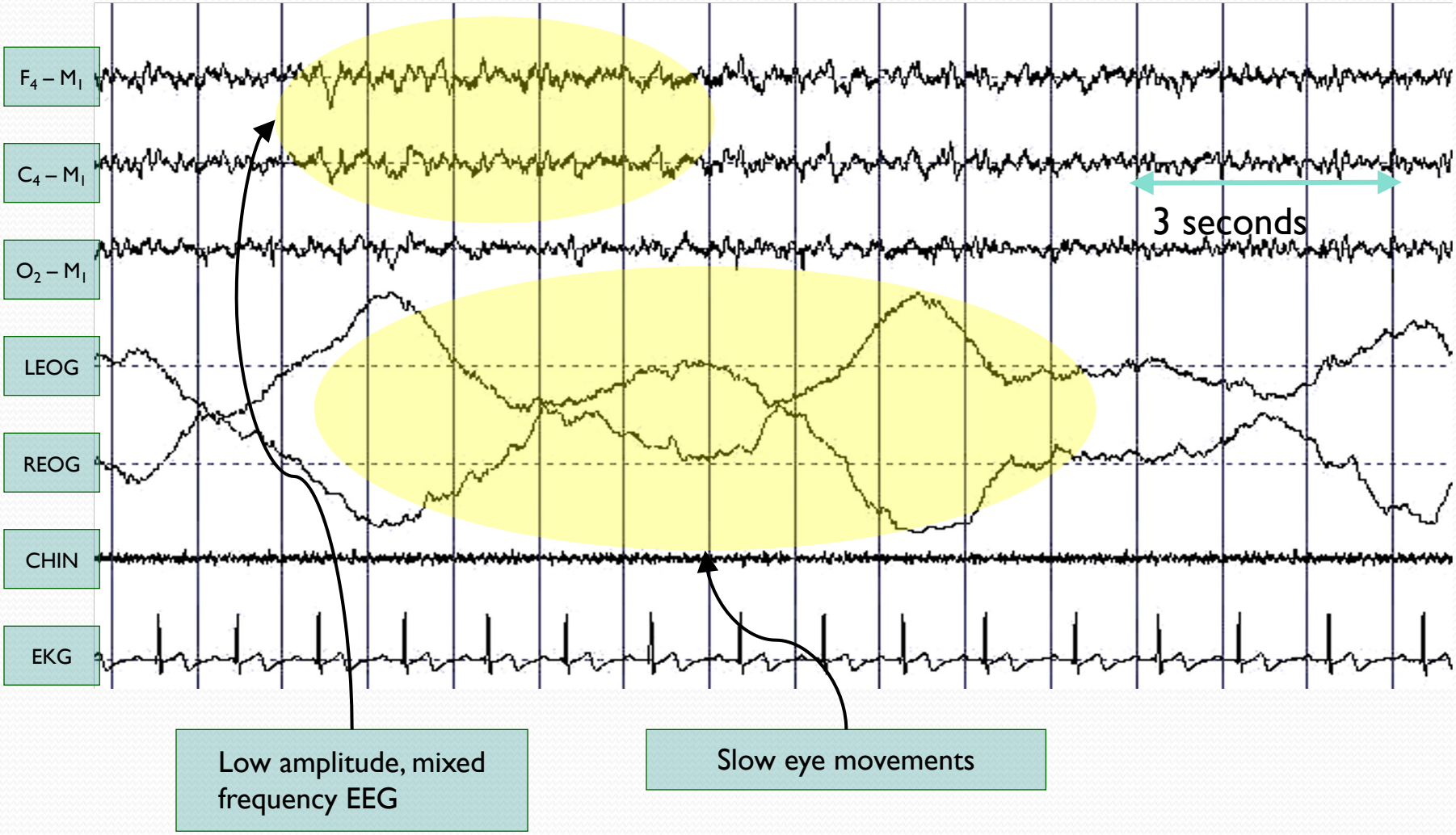
Vertex sharp waves



3 seconds

Slow eye movements

Stage N1– Rule B



Stage N1 – Rule C

- An epoch is scored as N1 if the majority meets the criteria for N1 in the absence of evidence of another sleep stage. Subsequent epochs with an EEG showing LAMF activity are scored as N1 until there is evidence for another sleep stage.

Post-Arousal Rules for N1

- If arousal in N2:
  - Score post-arousal as N1 if EEG exhibits LAMF activity without 1 or more K complexes and/or spindles until evidence for another stage of sleep
- If arousal in REM:
  - If followed by LAMF EEG without posterior dominant rhythm AND with slow eye movements, score as N1 even if chin remains low
    - Continue to score as N1 until evidence for another stage of sleep, usually N2 or REM

Additional Notes for N1

- Vertex sharp waves may be present but are not required for scoring Stage N1
- EOG will often show slow eye movements (SEM) in Stage N1, but these are not required for scoring N1
- During N1, the chin EMG amplitude is variable, but often lower than Stage W
- Because SEMs often occur before PDR (alpha) disappears, sleep latency may be slightly shorter for those who do not generate alpha
- Those with neurological impairments, encephalopathy, or epilepsy may show a theta pattern during wakefulness so would need an EEG slowing of >1 Hz from Stage W to score as N1