Scoring Sleep Stages: REM

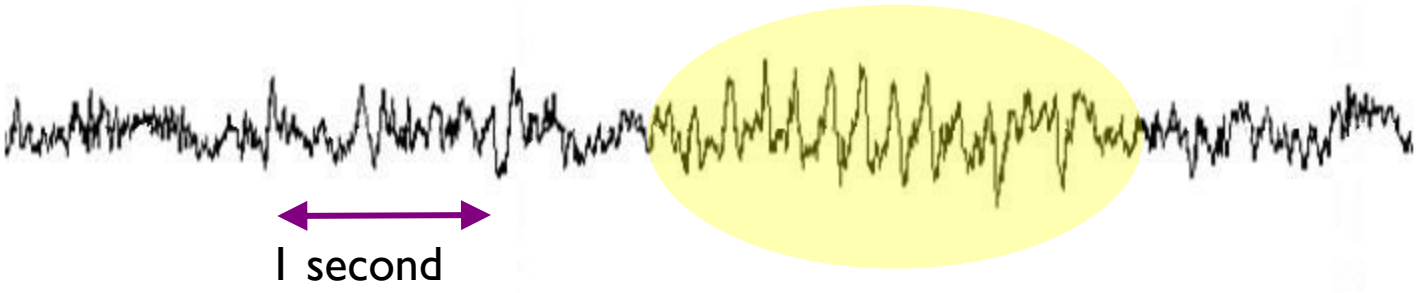
AASM REM Definitions

- Rapid eye movements (REMs): Eye movements recorded in the EOG derivations consisting of conjugate, irregular, sharply peaked eye movements with an initial deflection usually lasting <500 msec.
- Low chin EMG tone: Baseline EMG activity in the chin derivation no higher than in any other sleep stage and usually at the lowest level of the entire recording.

AASM REM Definitions

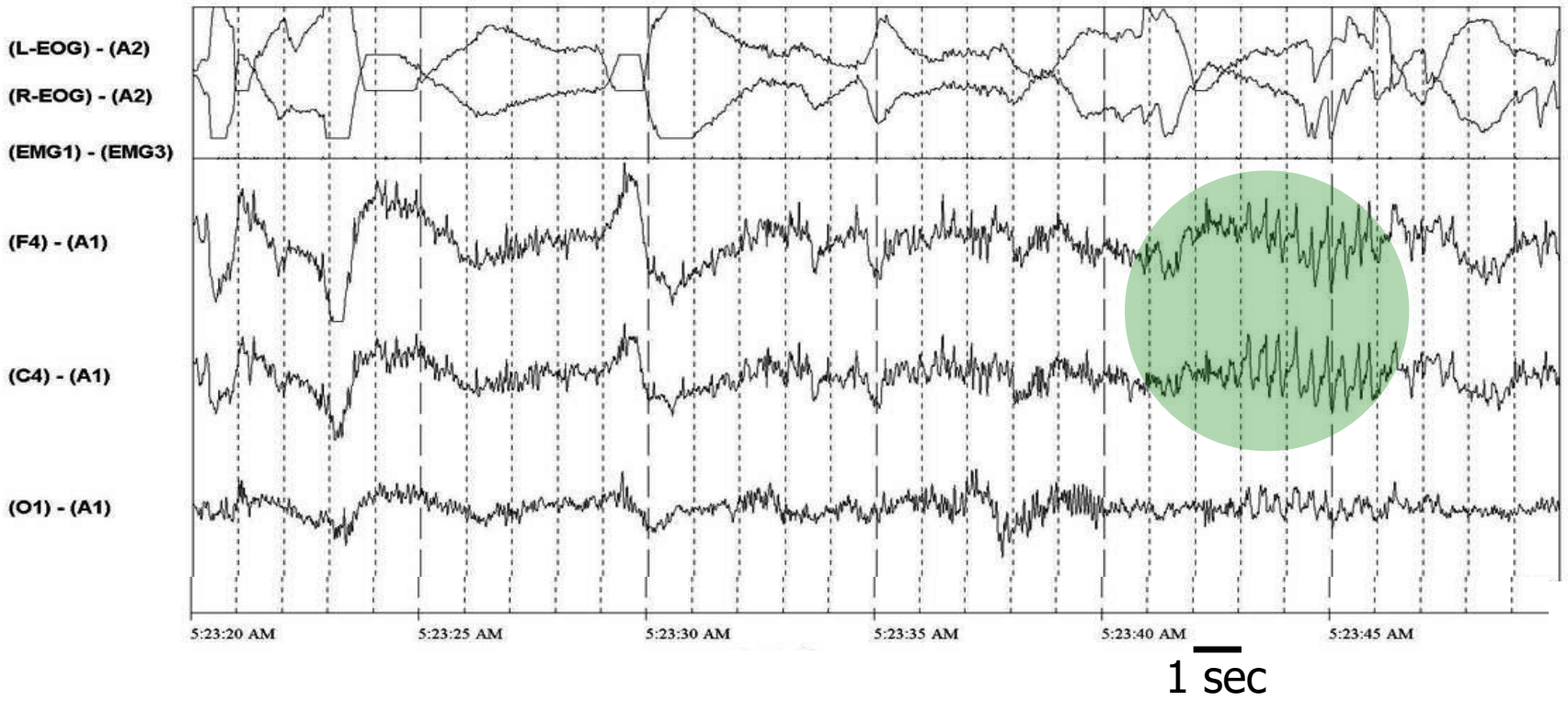
- Sawtooth waves: EEG pattern consisting of trains of sharply contoured or triangular, often serrated, 2-6 Hz waves maximal in amplitude in the central region and often, but not always, preceding a burst of REMs.
- Transient muscle activity: Short irregular bursts of EMG activity usually with a duration of <0.25 seconds superimposed on low EMG tone.

Sawtooth Waves
("Strongly Supportive" of REM)



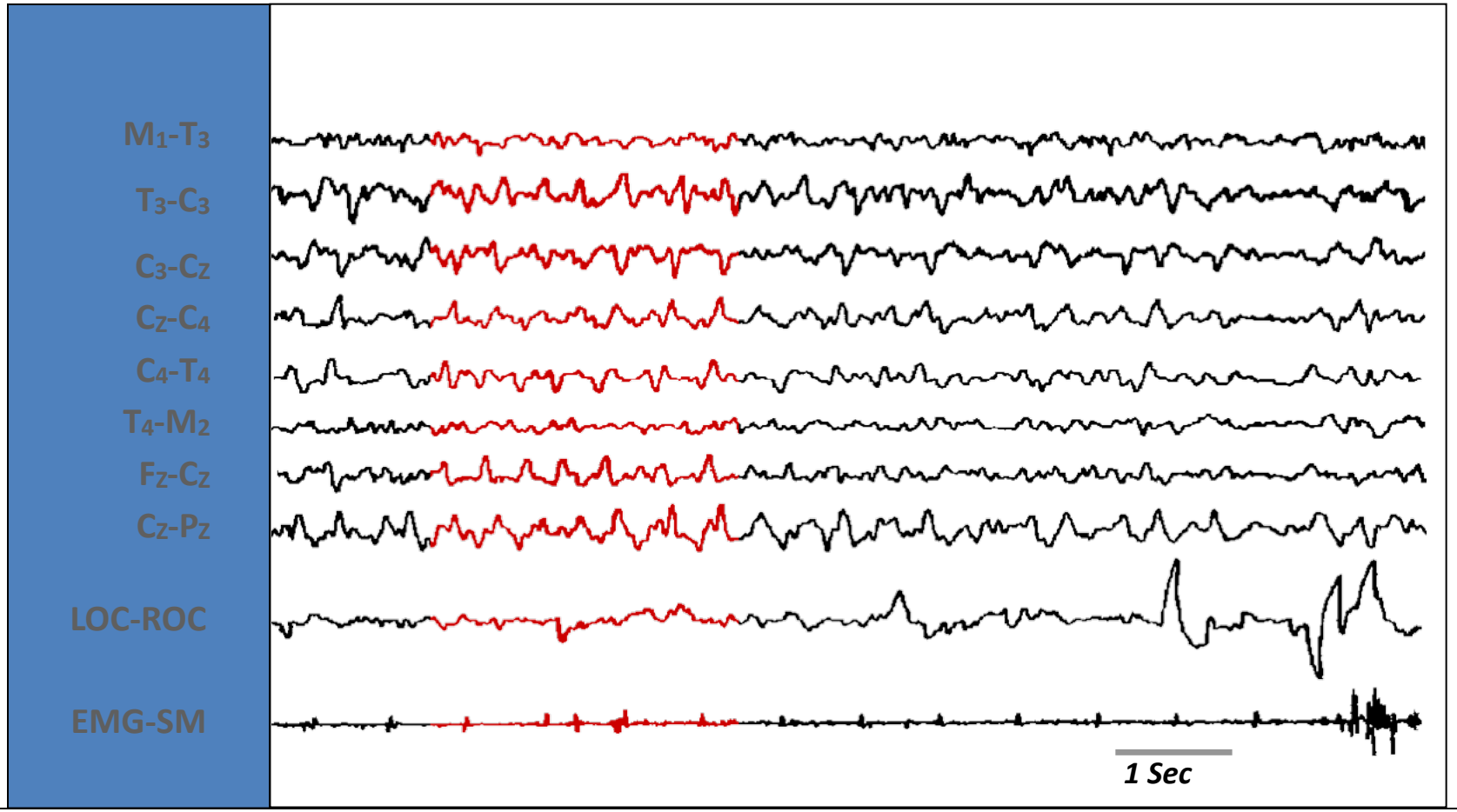
Sawtooth waves are trains of 2 to 6 Hz waves that look like the teeth on a hand saw. They frequently occur in conjunction with eye movements. They are most prominent in central derivations. The presence of sawtooth waves is strongly suggestive of REM sleep. However, the absence of sawtooth waves has no value in sleep stage scoring. Therefore, sawtooth waves are specific to REM but not sensitive to REM.

Sawtooth Waves



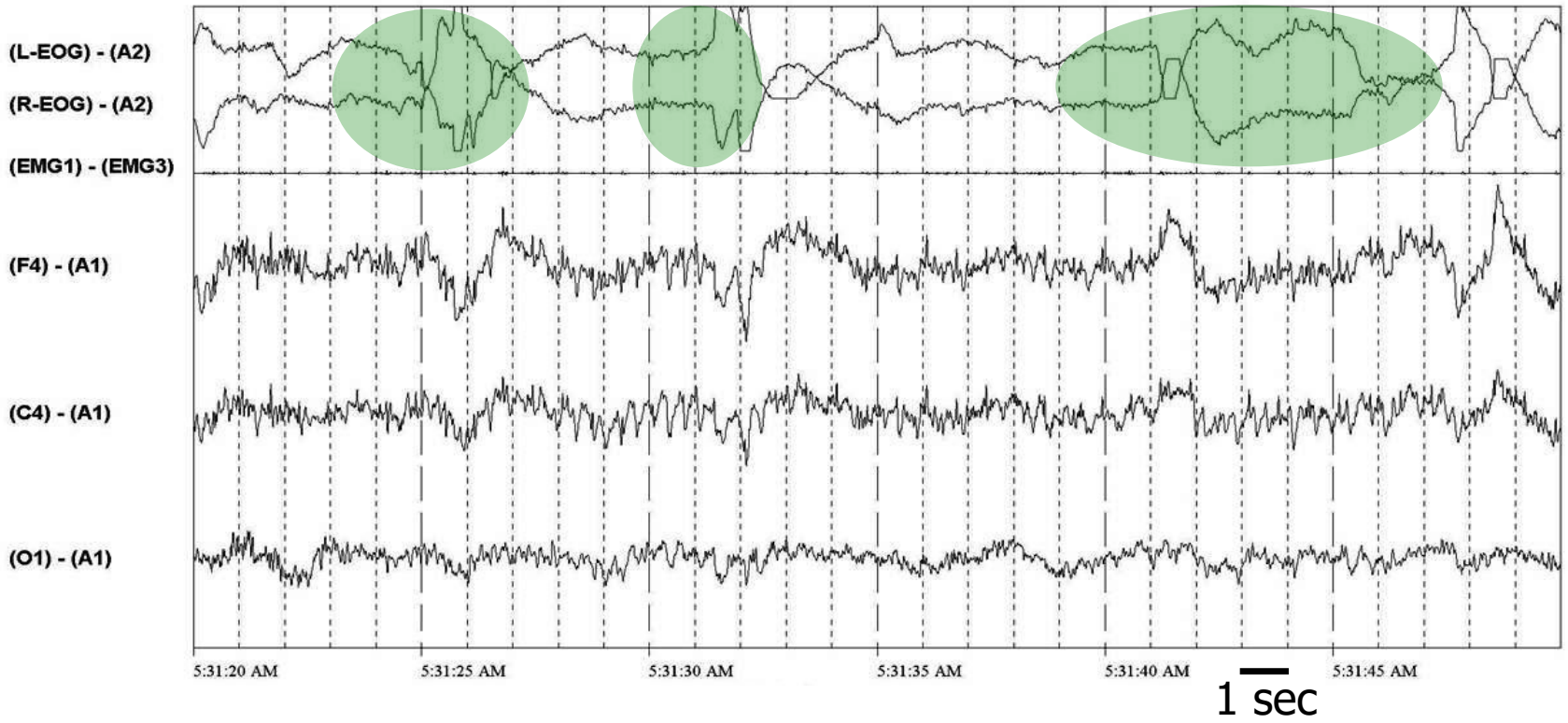
Sawtooth waves are considered a theta rhythm burst that can occur during REM sleep (highlighted in green on this slide). Theta is defined as EEG activity in the four to seven cps (4-7 Hz) frequency range. It differs from traditional theta activity in that the sawtooth waves have a distinctive notched appearance (thus, the name) and can be a bit slower in frequency than traditional theta. The total duration of the burst rarely exceeds 10 seconds.

Sawtooth Wave Distribution



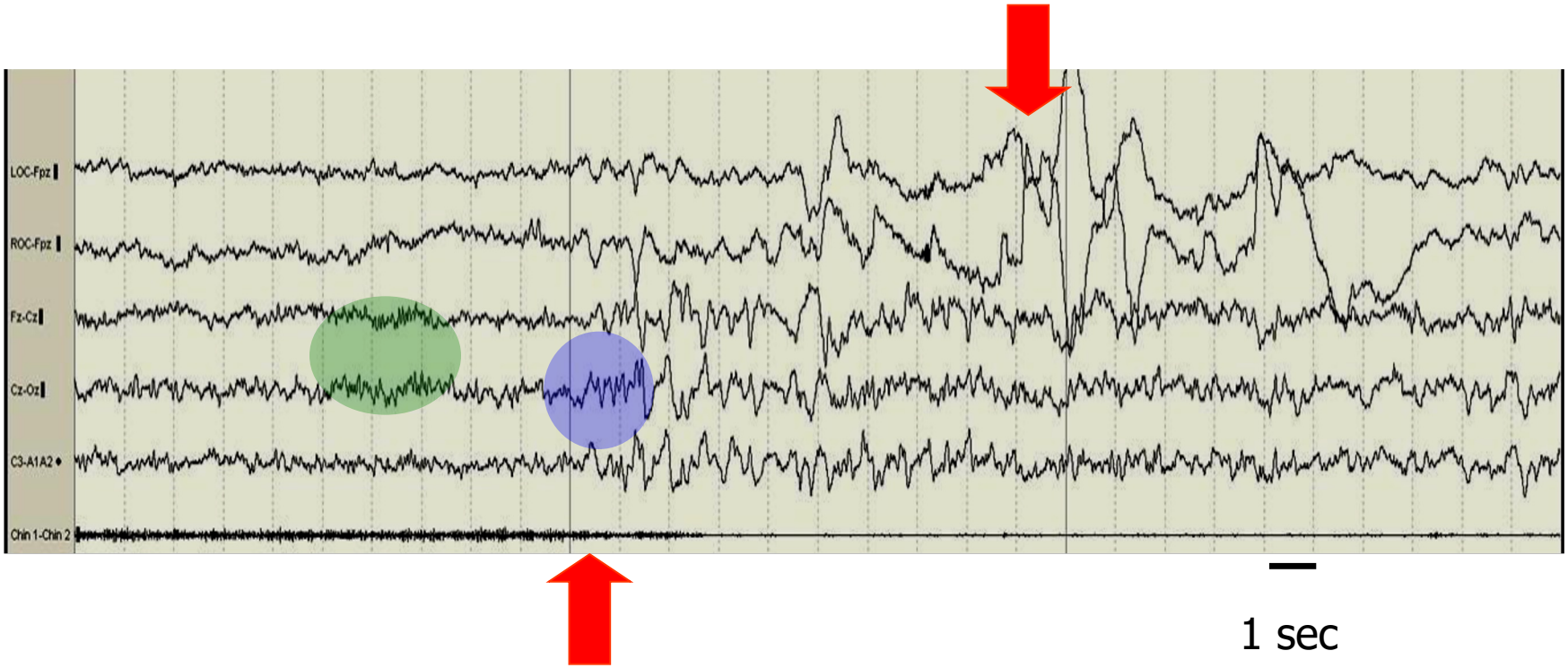
This illustration shows the scalp distribution of sawtooth theta waves (in red) recorded from a normal volunteer. In this recording, sawtooth waves are largest at the central parietal midline derivation. Frontal central midline and central temporal left and right hemispheres show prominent activity. Except for monopolar temporal channels, all EEG sites reveal sawtooth waves. A burst of rapid eye movement activity can be seen in the latter portion of this tracing on the single channel linking left and right eye activity.

Rapid Eye Movements (REM)



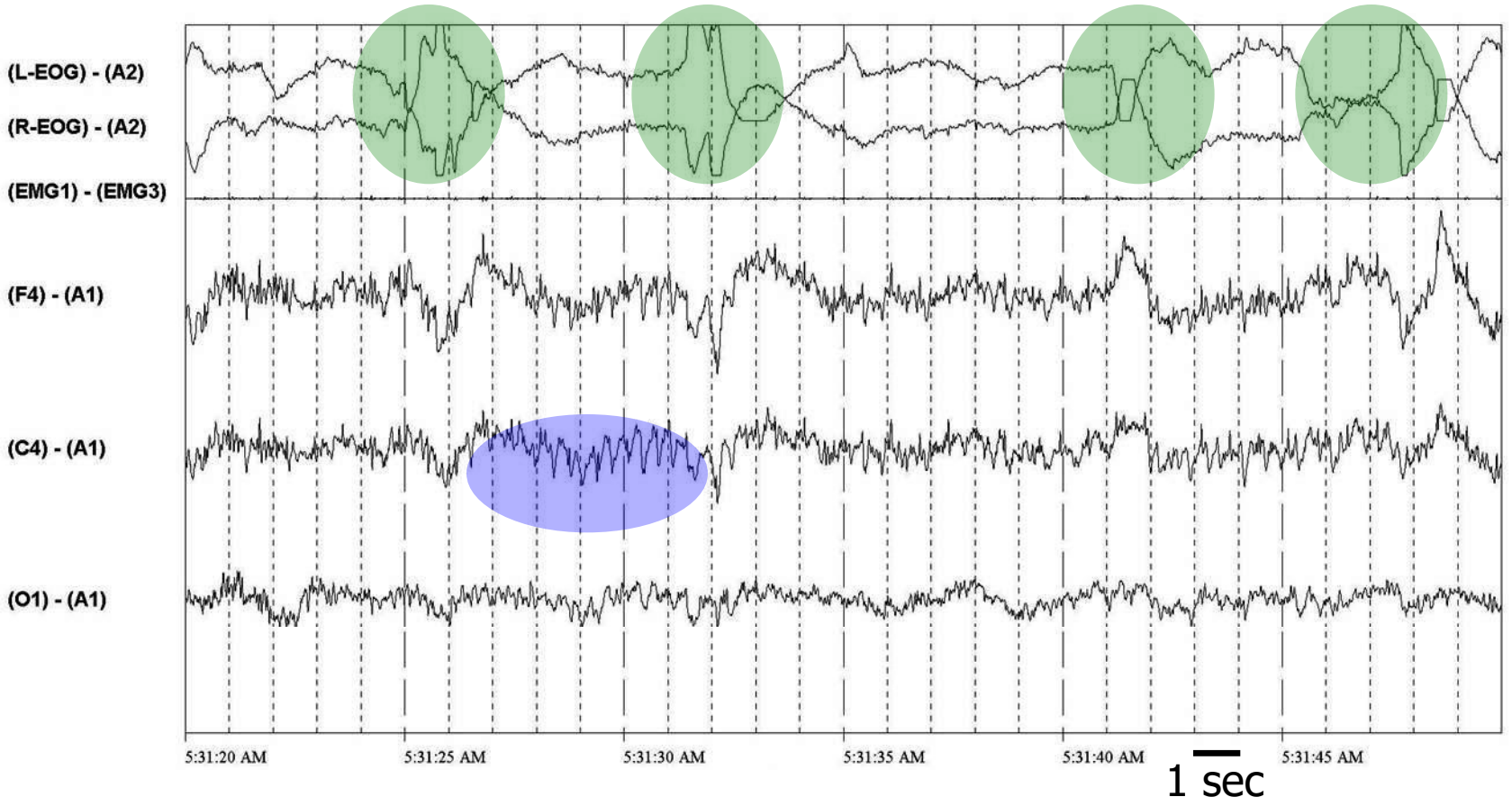
The rapid eye movement (REM) is one characterized by rapid, saccadic movement that may occur individually or in bursts (highlighted in green on this slide). The REM is one of the defining features of REM sleep. When recordings are made using standard technique, REMs can be differentiated from slow eye movements (SEMs). REMs are characteristically sharply peaked with an initial deflection usually lasting 0.5 seconds or less, while SEMs are more regular and sinusoidal, with an initial deflection usually lasting greater than 0.5 second.

Transition from Sleep Stage N2 to REM Sleep



The transition from sleep stage N2 to REM sleep is marked (upward red arrow). In the first segment of this 30-second polysomnographic epoch, we see a sleep spindle (highlighted in green). It is followed by a few sawtooth theta waves (highlighted in blue) and then rapid eye movements begin (downward red arrow). Submentalis EMG activity is absent.

REM Sleep



The slide shows a classic example of stage REM sleep. Low voltage, mixed frequency EEG is present throughout. Several bursts of eye movements (highlighted in green) are present and submental EMG activity is absent. There is also a burst of sawtooth waves (highlighted in blue).

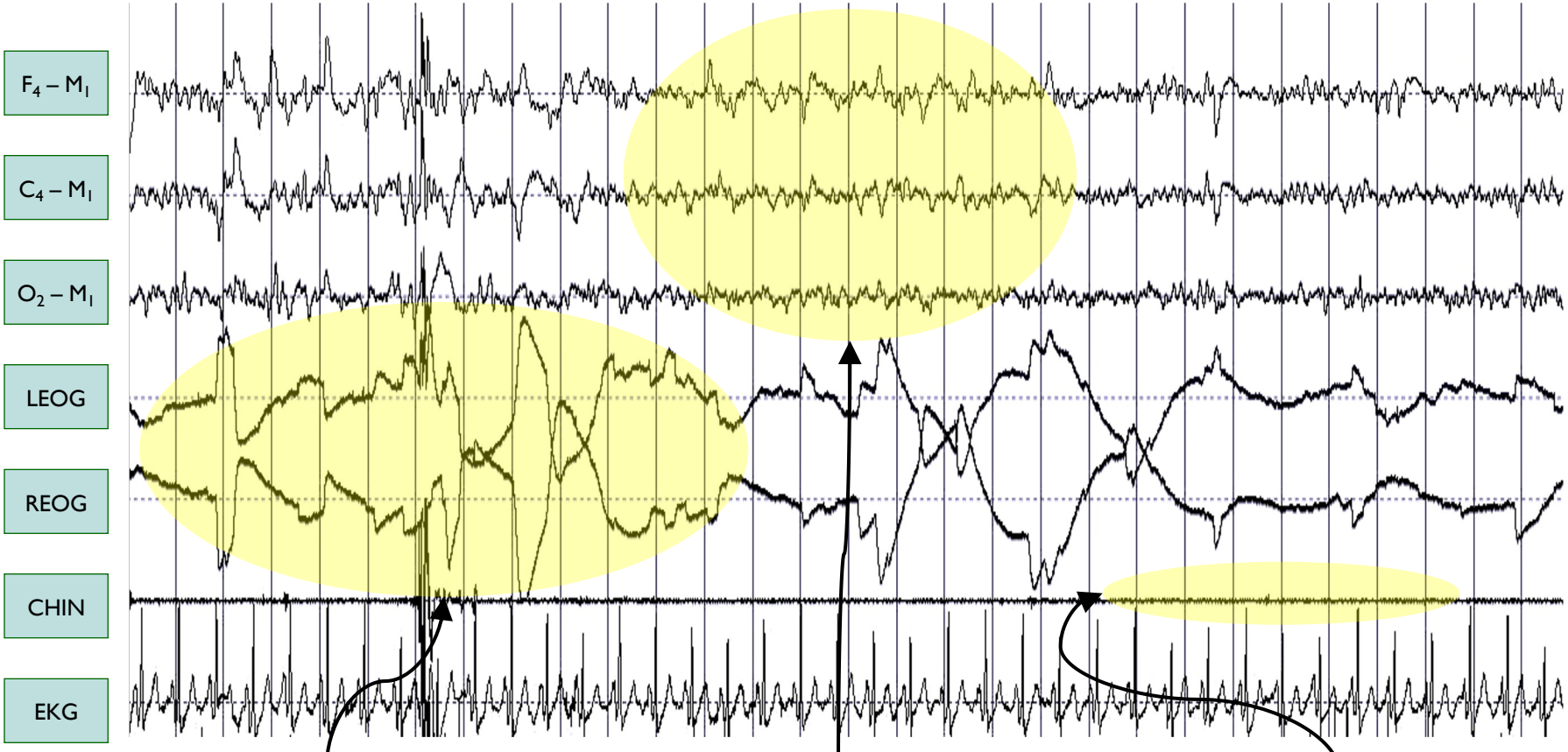
Stage Scoring Rules - REM

- Score stage R sleep in epochs with ALL the following phenomena (definite stage R):
  - LAMF EEG without K complexes or sleep spindles
  - Low chin EMG tone for most of the epoch and concurrent with REMs
  - Rapid eye movements at any position within the epoch
- Score segments of sleep preceding definite stage R, in the absence of REMs, as stage R if ALL are present:
  - EEG is LAMF without K-complexes or spindles
  - Chin EMG tone is low (at Stage R level)
  - No intervening arousal
  - SEMs following arousal or Stage W are absent

Stage Scoring Rules - REM

- If the majority of the epoch contains a segment of recording meeting criteria for Stage R, the epoch is scored as Stage R. Stage R rules take precedence over N2 rules.
- Continue to score epochs following definite Stage R, in the absence of REMs, as Stage R if ALL are present:
  - LAMF EEG without K-complexes or spindles
  - Low chin EMG tone (at Stage R level) for majority of epoch
  - No intervening arousal

Stage R



30 seconds per screen

Stage Scoring Rules – R (cont)

- Stop scoring stage R sleep when one or more of the following occur:
  - Transition to stage W or N3
  - Increase in chin EMG tone above the level of stage R for majority of epoch and criteria for stage N1 are met
  - An arousal occurs followed by LAMF EEG and slow eye movements (score as stage N1; if no slow eye movements and chin EMG tone remains low, continue to score as stage R)

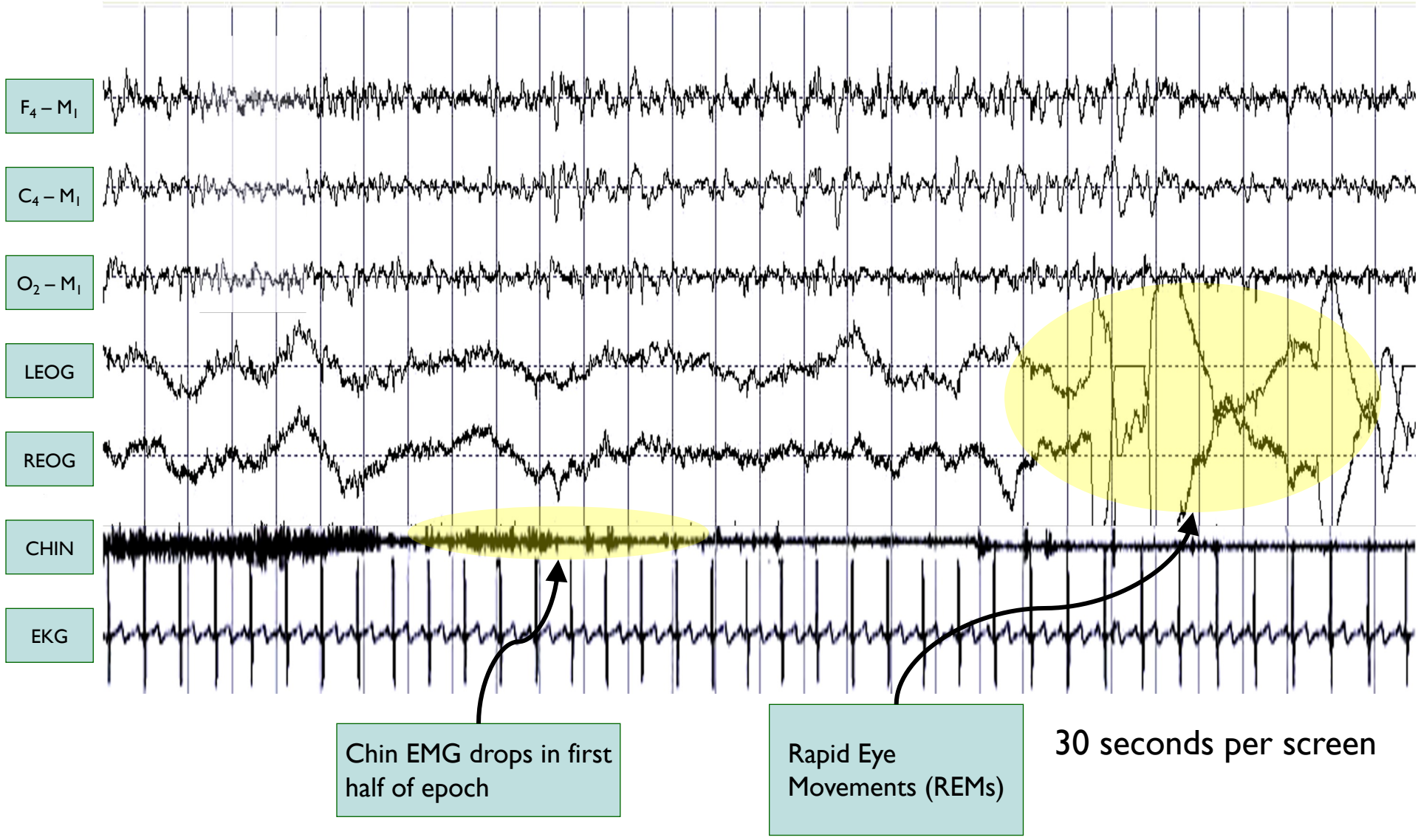
Stage Scoring Rules – R (cont)

- Stop scoring stage R sleep when one or more of the following occur:
  - A major body movement followed by slow eye movements and LAMF EEG without non-arousal associated K complexes or spindles (score the epoch following the major body movement as stage N1; if no slow eye movements and the EMG tone remains low, continue to score as stage R)
  - One or more non-arousal associated K complexes or spindles are present in the first half of the epoch in the absence of REMs, even if chin EMG tone remains low (score as stage N2)

Stage Scoring Rules – R (cont)

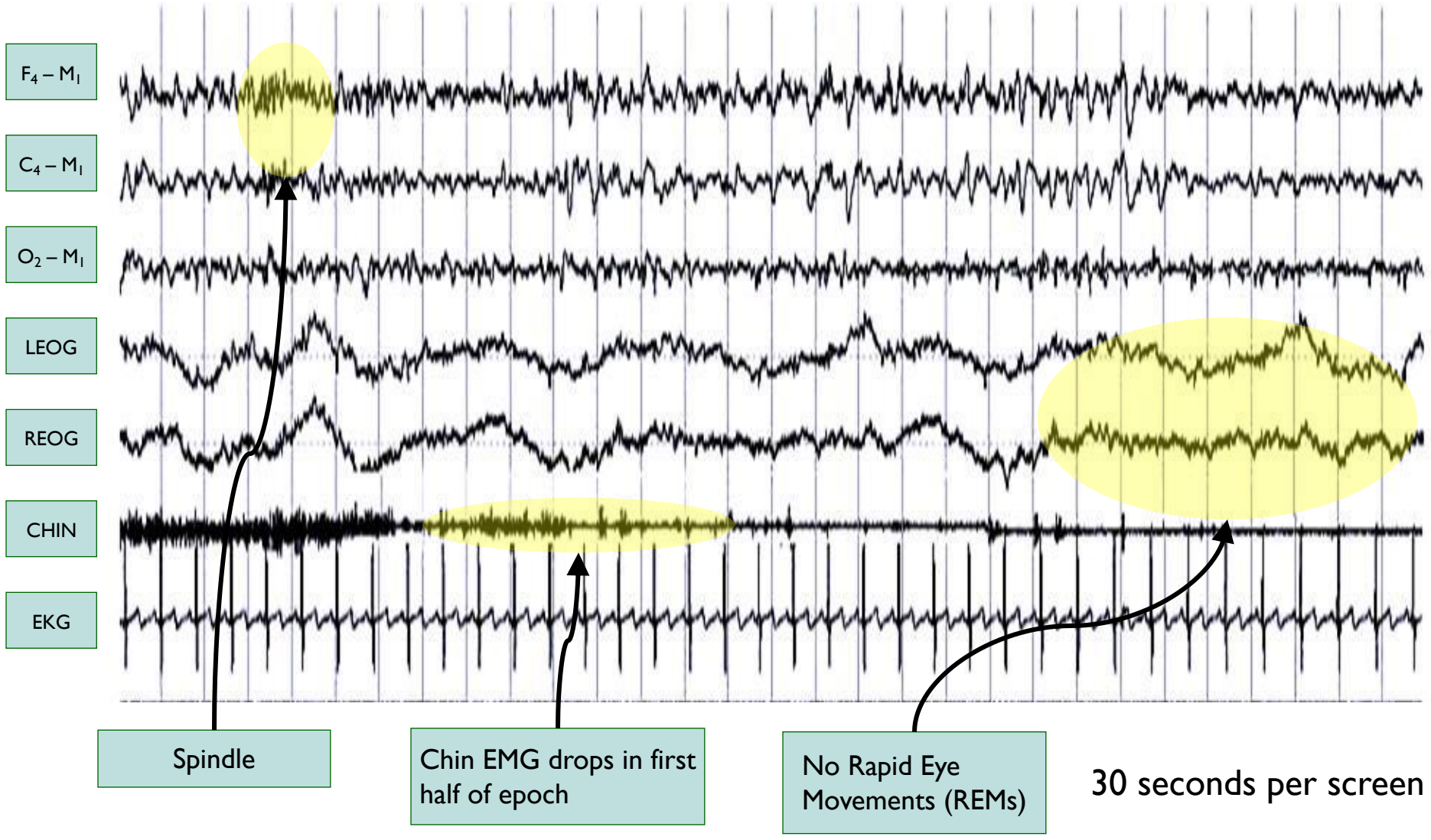
- Score epochs with low chin EMG and a mix of REMs and spindles and/or K complexes as follows:
  - Segments between two K complexes, two spindles, or a K complex and spindle without intervening REMs are Stage N2
  - Segments containing REMs without K complexes or spindles and chin EMG at stage R level are Stage R
  - If majority of epoch is N2, it is scored as N2
  - If majority of epoch is stage R, it is scored as stage R

Stage R


$F_4 - M_1$
$C_4 - M_1$
$O_2 - M_1$
LEOG
REOG
CHIN
EKG
Chin EMG drops in first half of epoch
Rapid Eye Movements (REMs)
30 seconds per screen

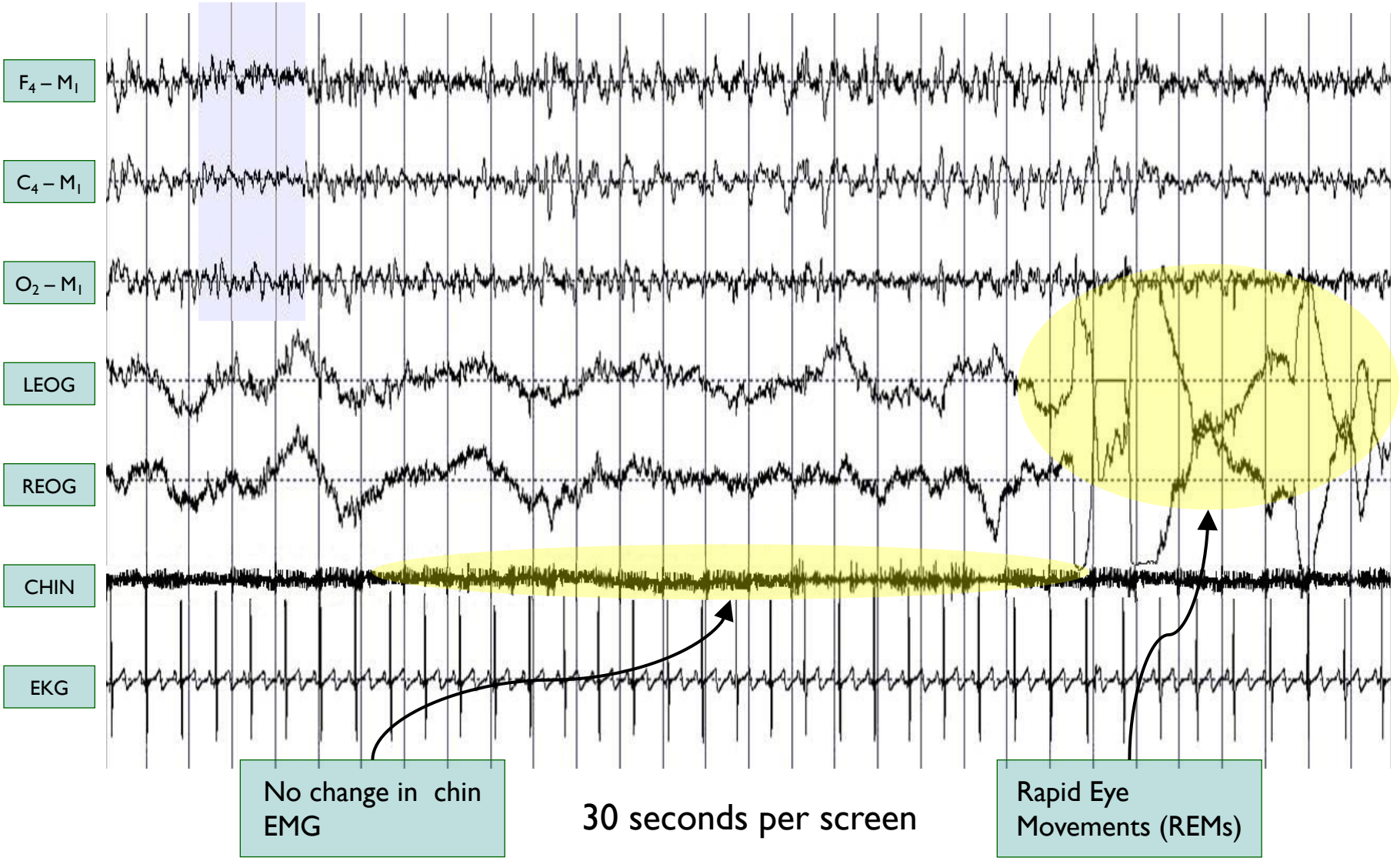
In this epoch, the chin EMG drops in the first half of the epoch but eye movements are not seen. A poorly formed spindle is seen in the first 5 seconds of the recording.

Stage N2



If the previous epoch was scored as N2, this epoch would be scored as R even though there is no drop in chin EMG. There are no sleep spindles. The EEG changes somewhat with the onset of rapid eye movements, but the entire epoch would be designated as having low voltage, mixed frequency EEG.

Stage R



Notes for Stage R

- LAMF in Stage R resembles that seen in N1. Some individuals will have a greater amount of alpha in Stage R than in N1. Alpha frequency in Stage R is often 1-2 Hz slower than during Wake.
- Sawtooth waves and transient muscle activity are not required for scoring Stage R.
- SEMs can occur during Stage R, but SEMs following an arousal in combination with EEG showing LAMF suggests transition to N1 even if chin tone remains low.
- Segments of the record with low chin EMG and a mix of REM and spindles and/or K complexes usually occur during first REM period of the night.