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Workstation 3

Scoring and Interpreting polysomnography and polygraphy in adults

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Conflict of interest disclosure

- There is no real or perceived conflicts of interest that relate to this presentation.

Workstation 3

- Indications for sleep studies in adults
- Scoring sleep in adults
- Scoring respiratory events during sleep in adults
- Normal values for adult sleep studies and polygraphy
- Indications for treatment of sleep disordered breathing in adults
- Case-based discussion

Indications for sleep studies in adults

- Many sleep disorders can be diagnosed clinically
- BUT many require full evaluation in a sleep laboratory
- PSG (and PG) recommended in sleep-related breathing disorders
- PSG recommended for evaluating parasomnias
- PSG and daytime testing important in evaluating hypersomnia
- Insomnia, RLS and circadian rhythm disturbances - evaluated using other methods

What can PSG show us?

- Measures physiological data during sleep and wake overnight

- Gives information on
  - Duration/amount of sleep
  - Patterns of sleep
  - Quality of sleep
  - Behaviours during sleep

How do we deal with the data?

Scroll through study several times:

- Sleep staging – 30s epoch
- EEG arousals – 30s epoch
- Respiratory events – 2min / 5min epoch
  - 10min epoch to screen for Cheyne-Stokes
- Periodic leg movements – 5min epoch

Scoring sleep in adults

- Based on unit of epoch
  - 30s in most labs
- Each epoch reviewed in turn and assessed as a whole for its sleep stage
- In some situations, the page before or after can influence the decision
- To score a certain stage of sleep at least half the epoch (15 seconds) must be classified as that stage

Scoring Criteria

- Each stage of sleep defined by certain characteristics

- Rechtschaffen and Kales (1968)
- AASM Manual for the Scoring of Sleep and Associated Events (2007)
  - Version 2.0 (2012)
  - Version 2.1 (2014)
  - Version 2.2 (2015)
  - Version 2.3 (2016)

Sleep stages

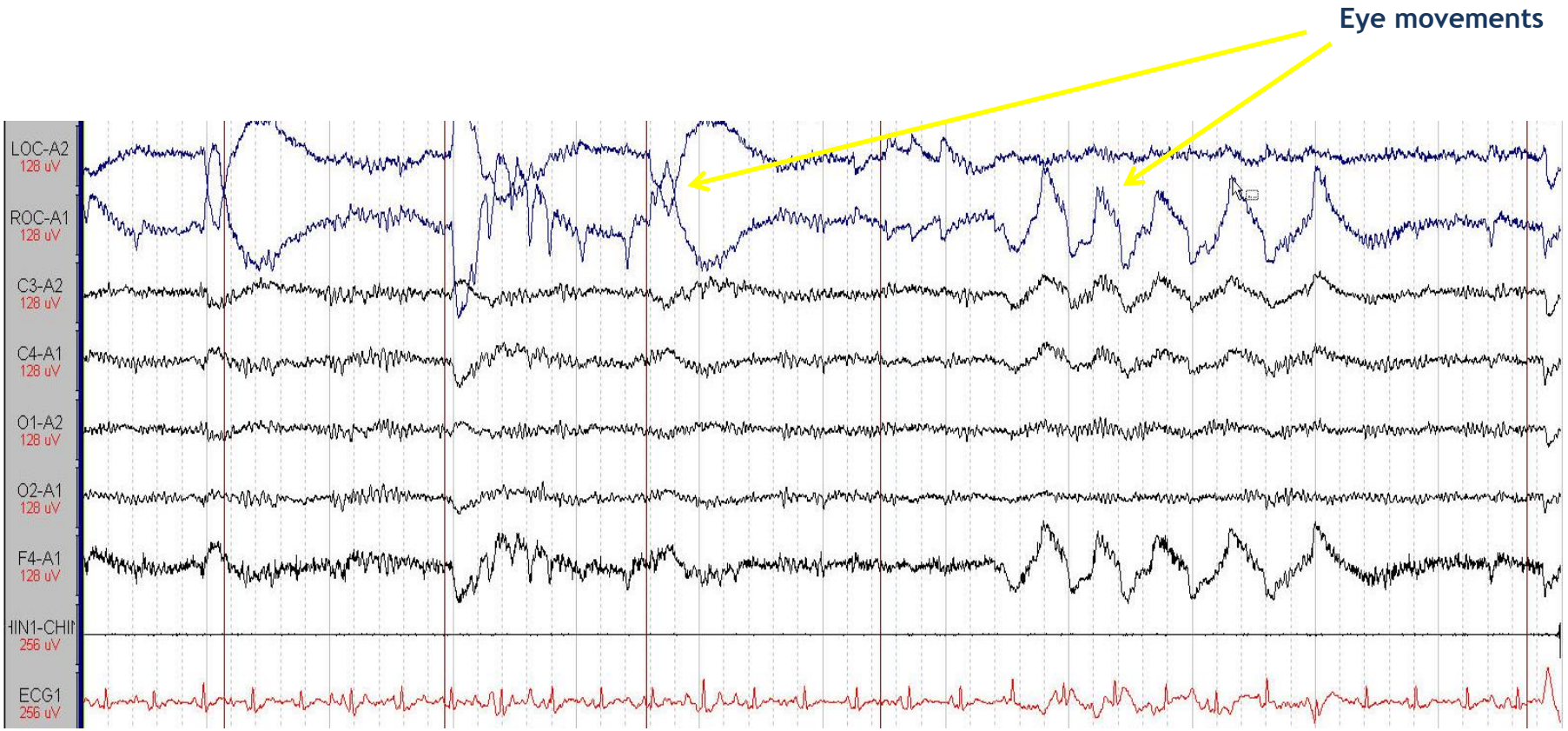
R&K (1968)		*AASM (2007)*
0 / Wake	⇢	W
1	⇢	N1
2	⇢	N2
3	⇢	N3
4	⇢	
REM	⇢	REM

Stage W

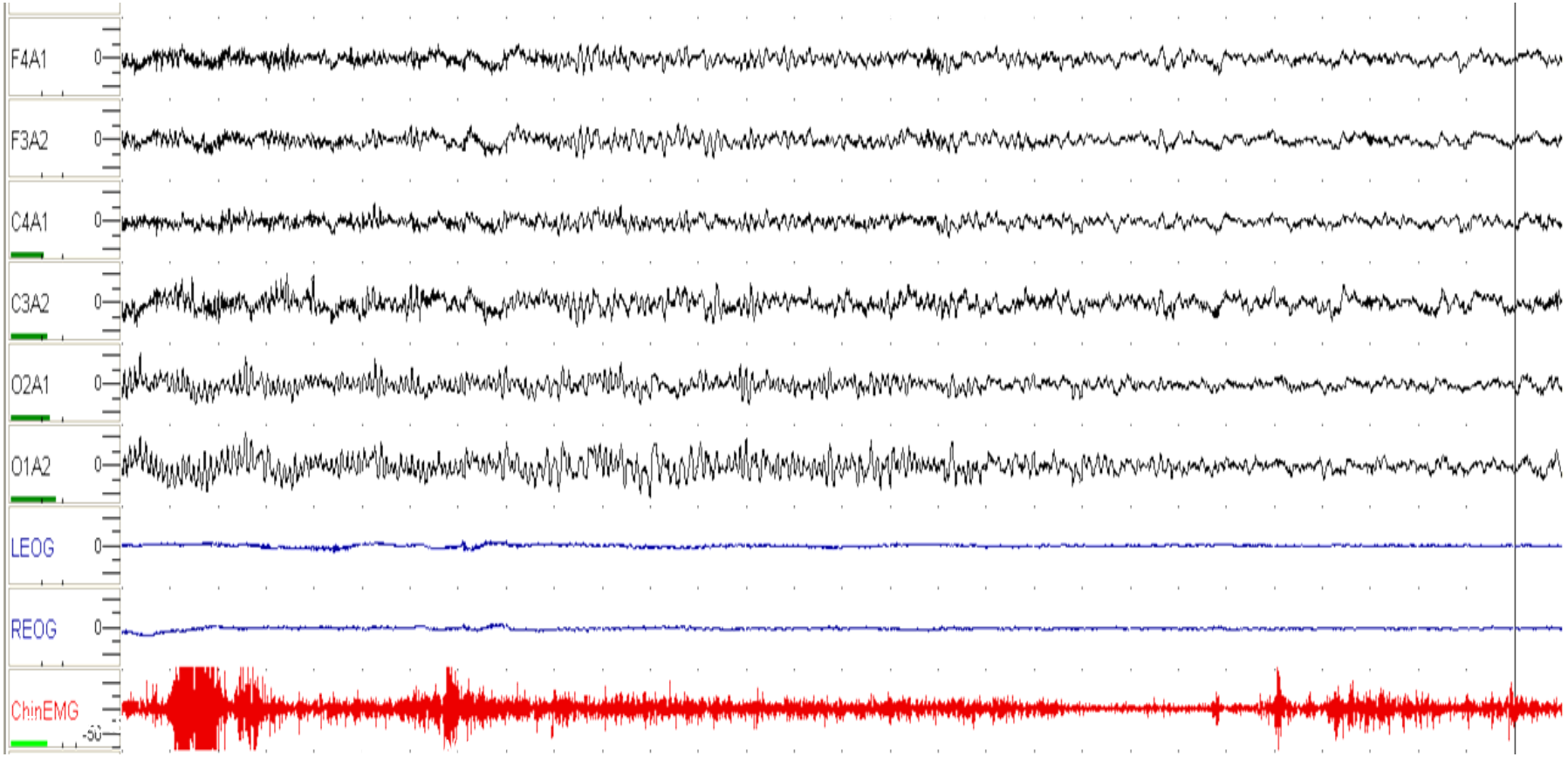
- Eyes open
  - fast beta activity (>13Hz) on EEG
  - high EMG tone
  - EOG blinks

- Eyes closed
  - alpha waves (8-13Hz) – in some, not all
  - clearest on occipital EEG

Stage W


Eye movements
LOC-A2
128 uV
ROC-A1
128 uV
C3-A2
128 uV
C4-A1
128 uV
O1-A2
128 uV
O2-A1
128 uV
F4-A1
128 uV
256 uV
ECG1
256 uV

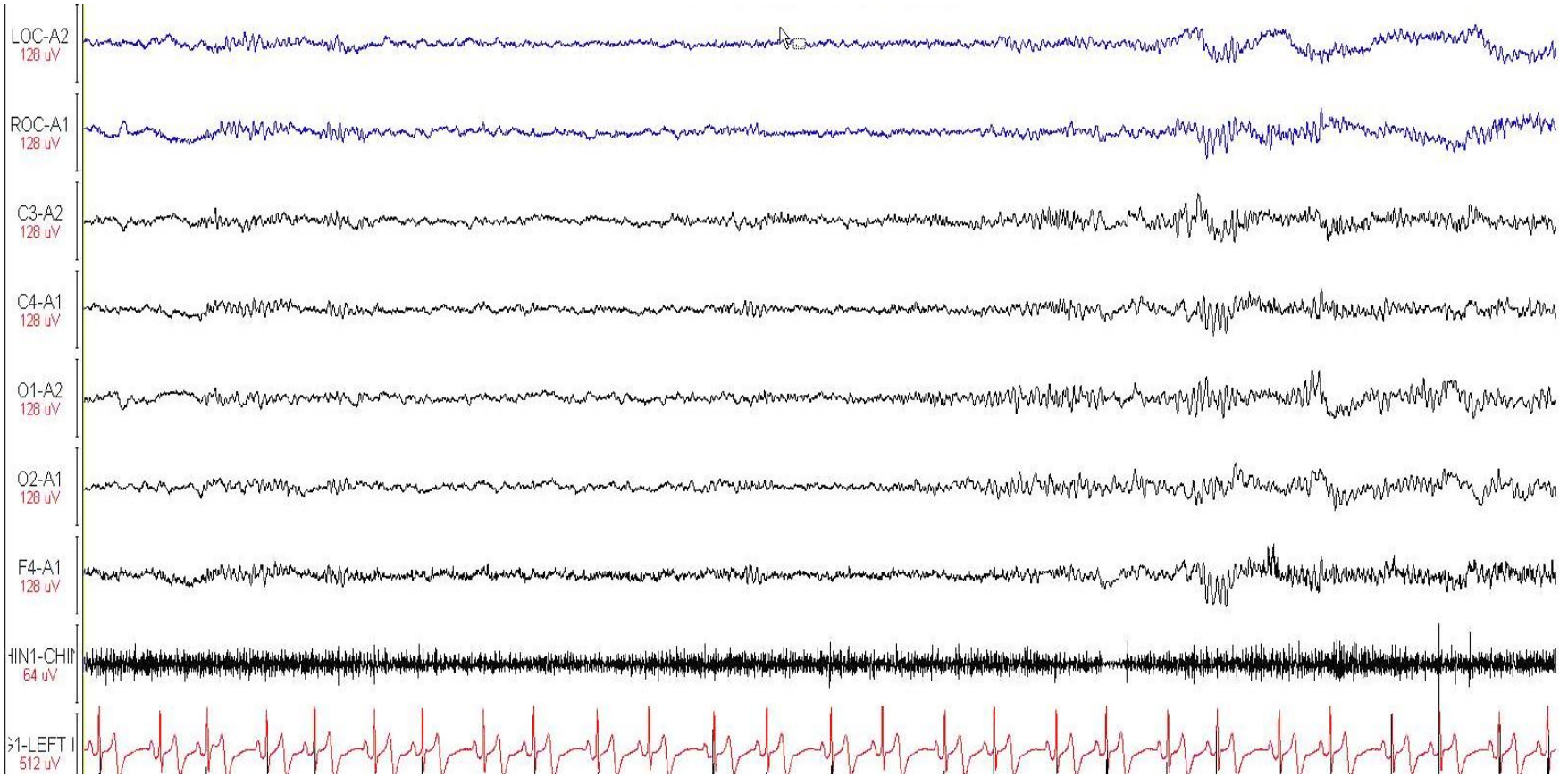
Stage W



Stage N1

- Theta activity (4-7Hz) on EEG
  - Vertex sharp waves - clearest on central EEG
- Rolling eye movements on EOG
  - often accompanied by ↓ in EMG

Stage N1


LOC-A2
128 uV
ROC-A1
128 uV
C3-A2
128 uV
C4-A1
128 uV
O1-A2
128 uV
O2-A1
128 uV
F4-A1
128 uV
64 uV
512 uV

Stage N2

- Presence anywhere on page of:
  - Sleep spindle
    - fast burst (0.5–2s) of 12 –15Hz activity
    - clearest on central EEG

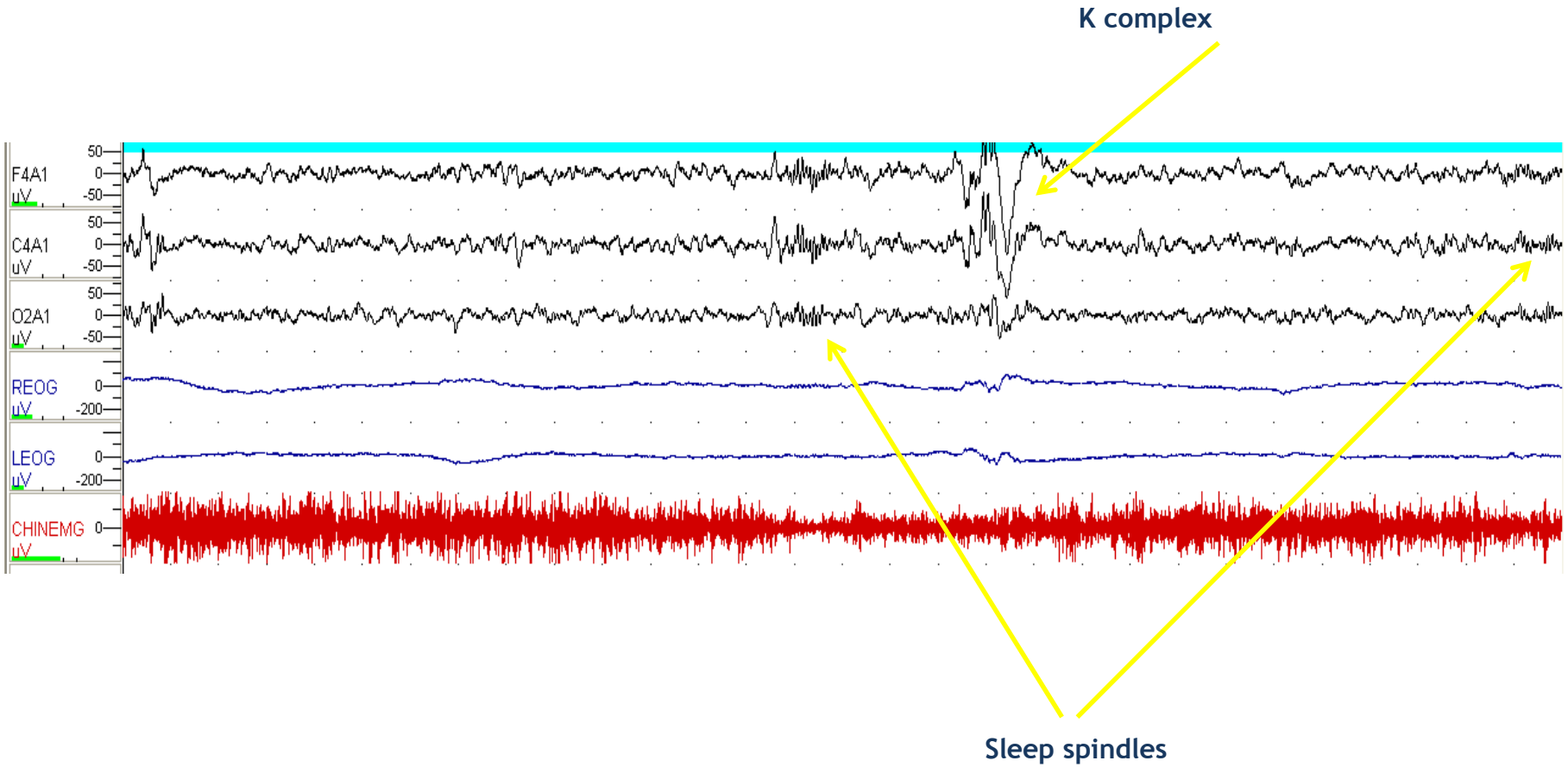
    OR
  - K complex
    - -ve EEG deflection followed by +ve
    - clearest on frontal EEG

- Background - low voltage, mixed frequency EEG

Stage N2

- Keep scoring stage N2 until:
  - change to any other stage (except N1)
  - arousal
  - major body movement
  - No “3-minute rule”

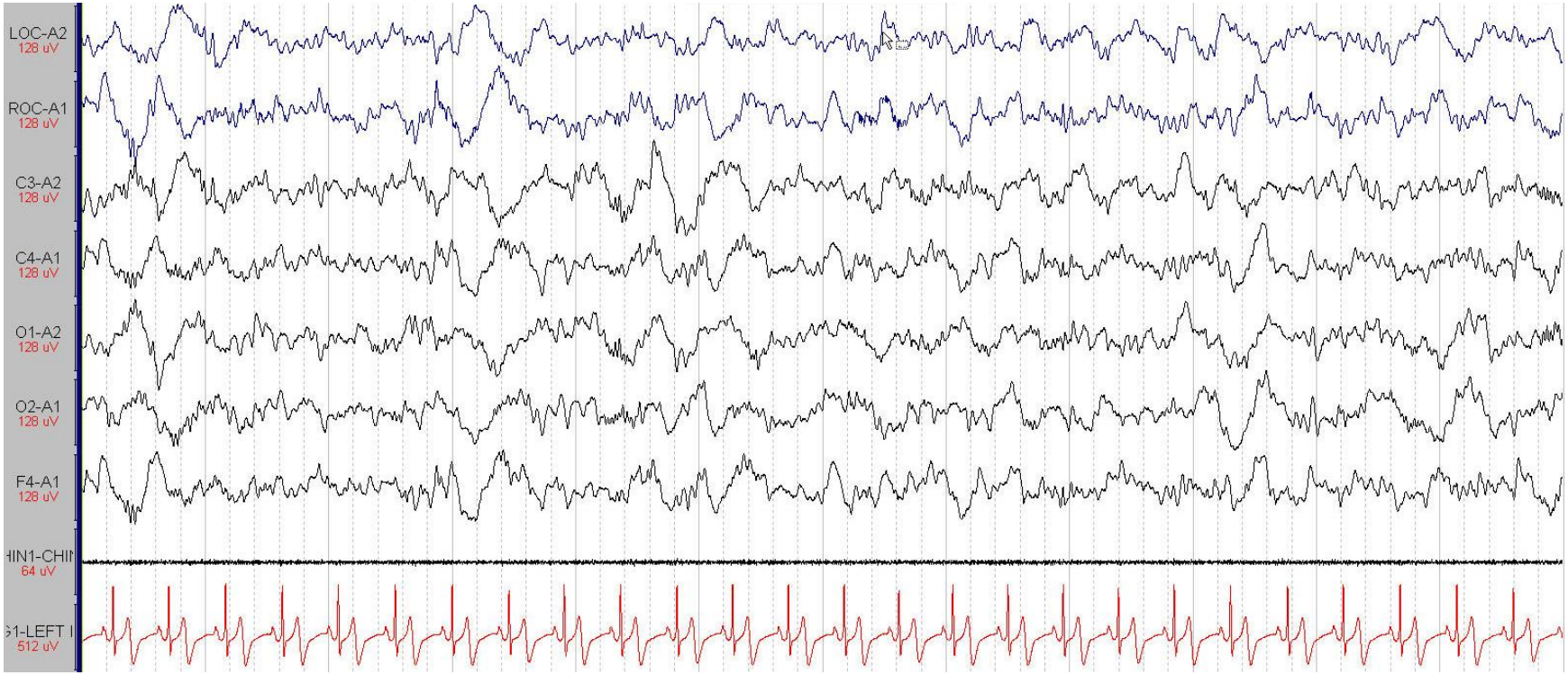
Stage N2



Stage N3

- Delta/slow waves in ≥20% (≥6s) of epoch
  - 0-3 Hz, ≥75μV in amplitude
- Do not confuse K complexes with slow waves
  - K complexes separated in time
  - slow waves tend to occur in runs

Stage N3


LOC-A2
128 uV
ROC-A1
128 uV
C3-A2
128 uV
C4-A1
128 uV
O1-A2
128 uV
O2-A1
128 uV
F4-A1
128 uV
64 uV
512 uV

Stage R

- Bursts of rapid eye movements on EOG
  - Not on every page
- Very low amplitude EMG (atonia)
- Low voltage, mixed frequency EEG
  - Similar to stage N1
- Sawtooth waves
  - clearest on central EEG
  - Often precede bursts of REMs
- Phasic twitches on EMG

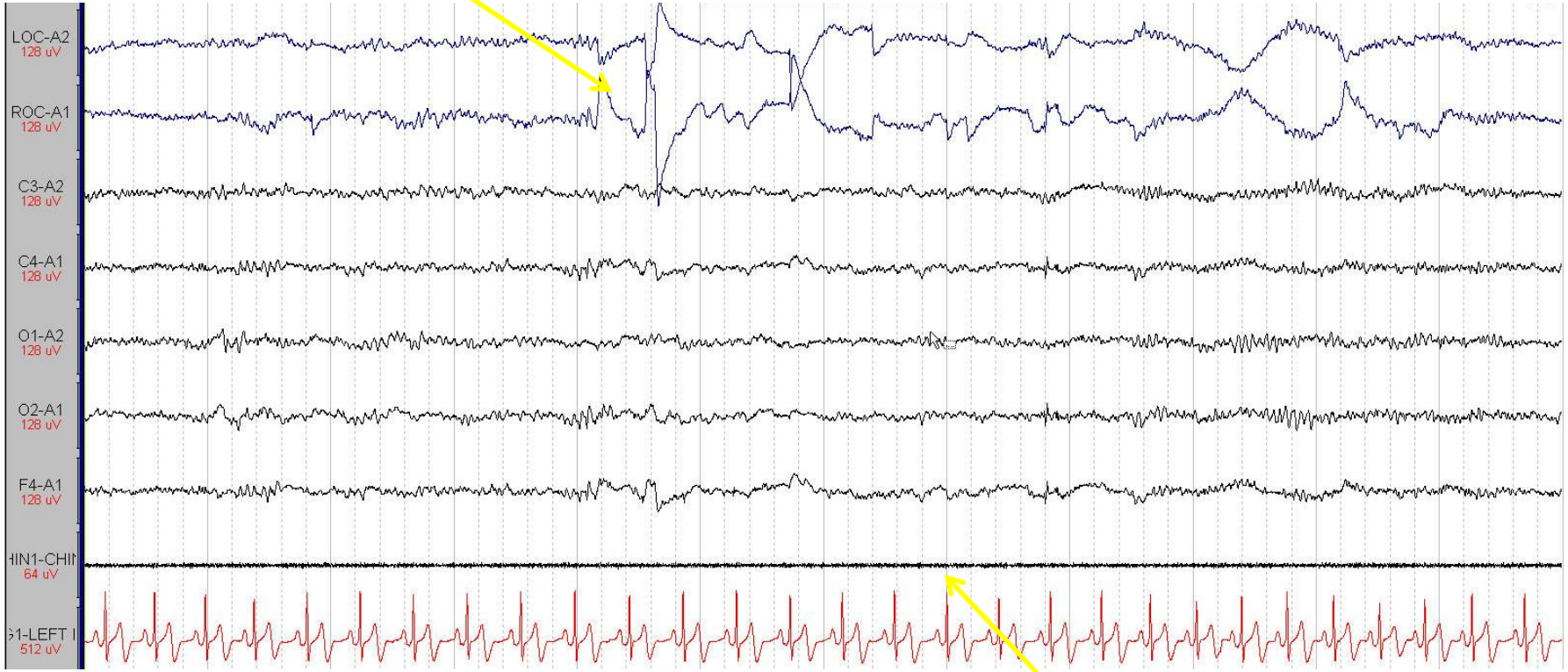
Stage R

- Onset of stage R:
  - first appearance of low voltage, mixed frequency EEG, REMs and low EMG

- Stop scoring REM when there is:
  - change to stage W or stage N3
  - ↑ EMG tone
  - arousal followed by low amplitude, mixed frequency EEG with slow rolling eye movements (N1)
  - major body movement followed by SEMs without a sleep spindle or K complex
  - sleep spindle or K complex present in first 15s of an epoch in absence of eye movements

Stage REM

Burst of rapid eye movements



Loss of muscle tone (atonia)

Scoring respiratory events during sleep in adults

- Apnea (Central, obstructive, mixed)
- Hypopnea (Central, obstructive)
- Respiratory effort related arousals (RERA)

Dertermination of the duration of the events

AASM recommandations

SLEEP–RELATED BREATHING DISORDERS IN ADULTS

Sleep–Related Breathing Disorders in Adults: Recommendations for Syndrome Definition and Measurement Techniques in Clinical Research

The Report of an American Academy of Sleep Medicine Task Force

Chicago 1999

American Academy of Sleep Medicine Task Force. Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. The Report of an American Academy of Sleep Medicine Task Force. *Sleep* 1999;22:667-89.

The AASM Manual *for the* Scoring *of* Sleep *and* Associated Events

Rules, Terminology and Technical Specifications

AASM 2007

Conrad Iber, MD, Sonia Ancoli-Israel, PhD, Andrew L. Chesson Jr., MD and Stuart F. Quan, MD for the American Academy of Sleep Medicine

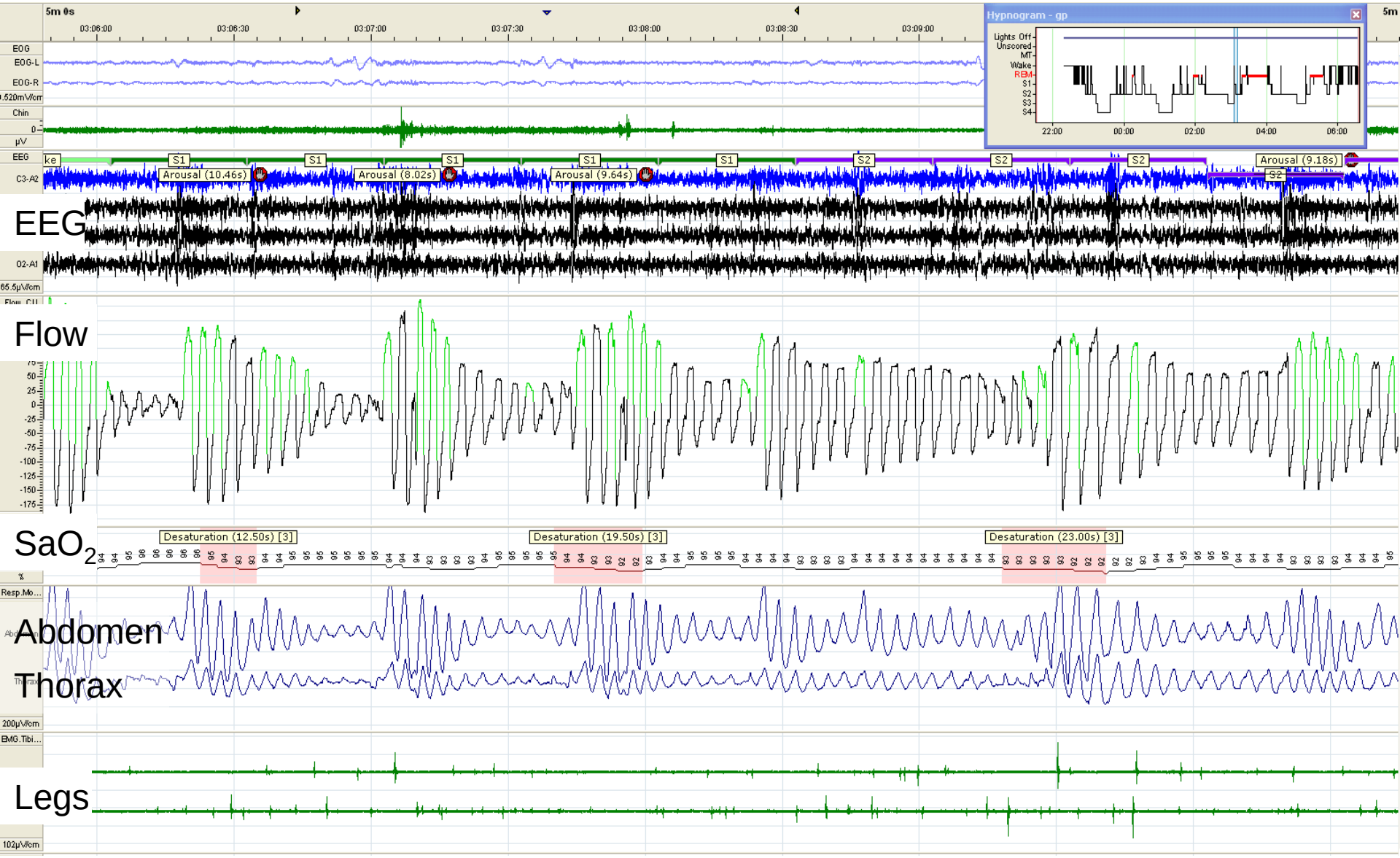
American Academy of Sleep Medicine, Westchester, IL

Rules for Scoring Respiratory Events in Sleep: Update of the 2007 AASM Manual for the Scoring of Sleep and Associated Events

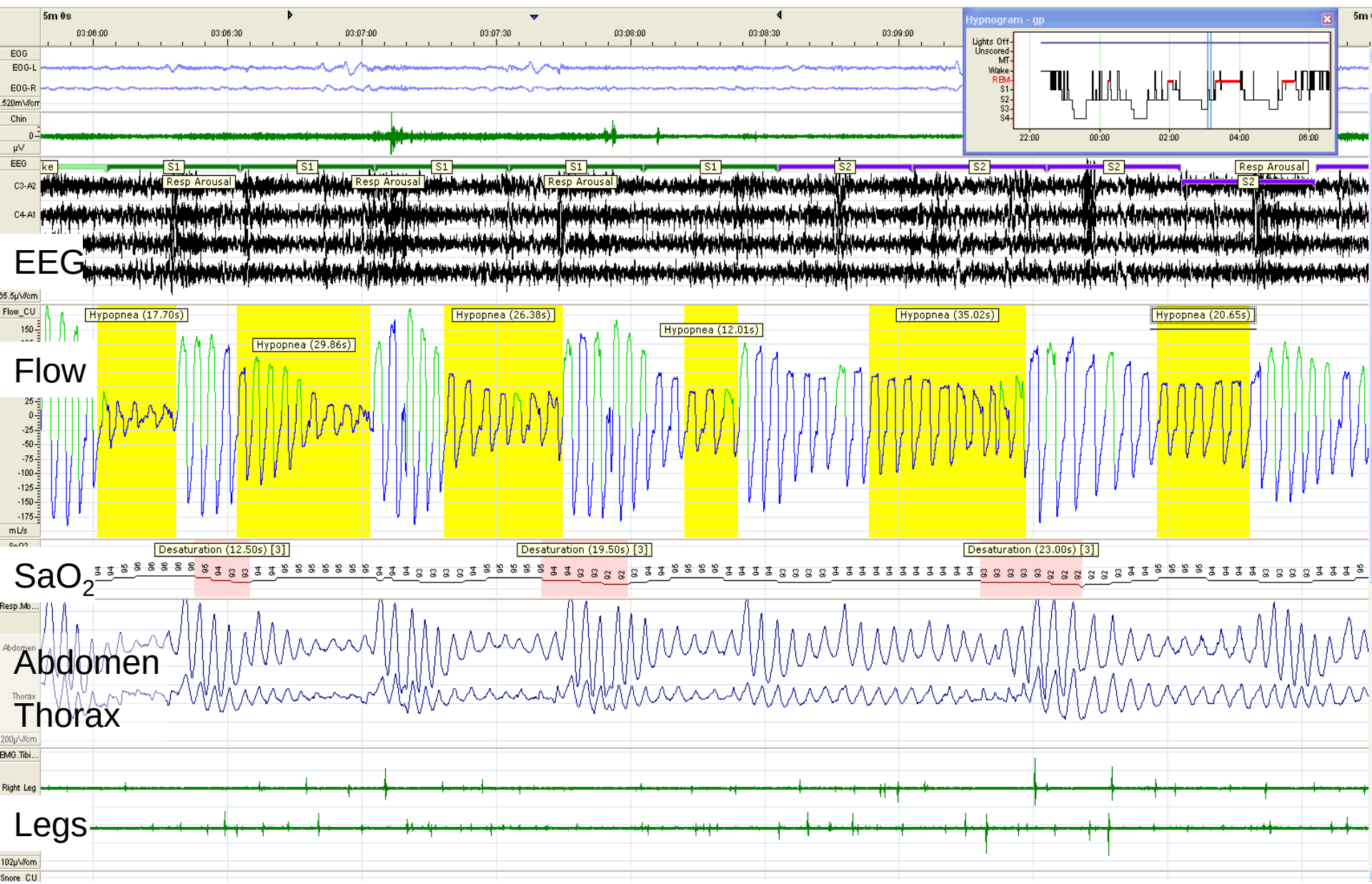
Deliberations of the Sleep Apnea Definitions Task Force of the American Academy of Sleep Medicine

AASM 2013

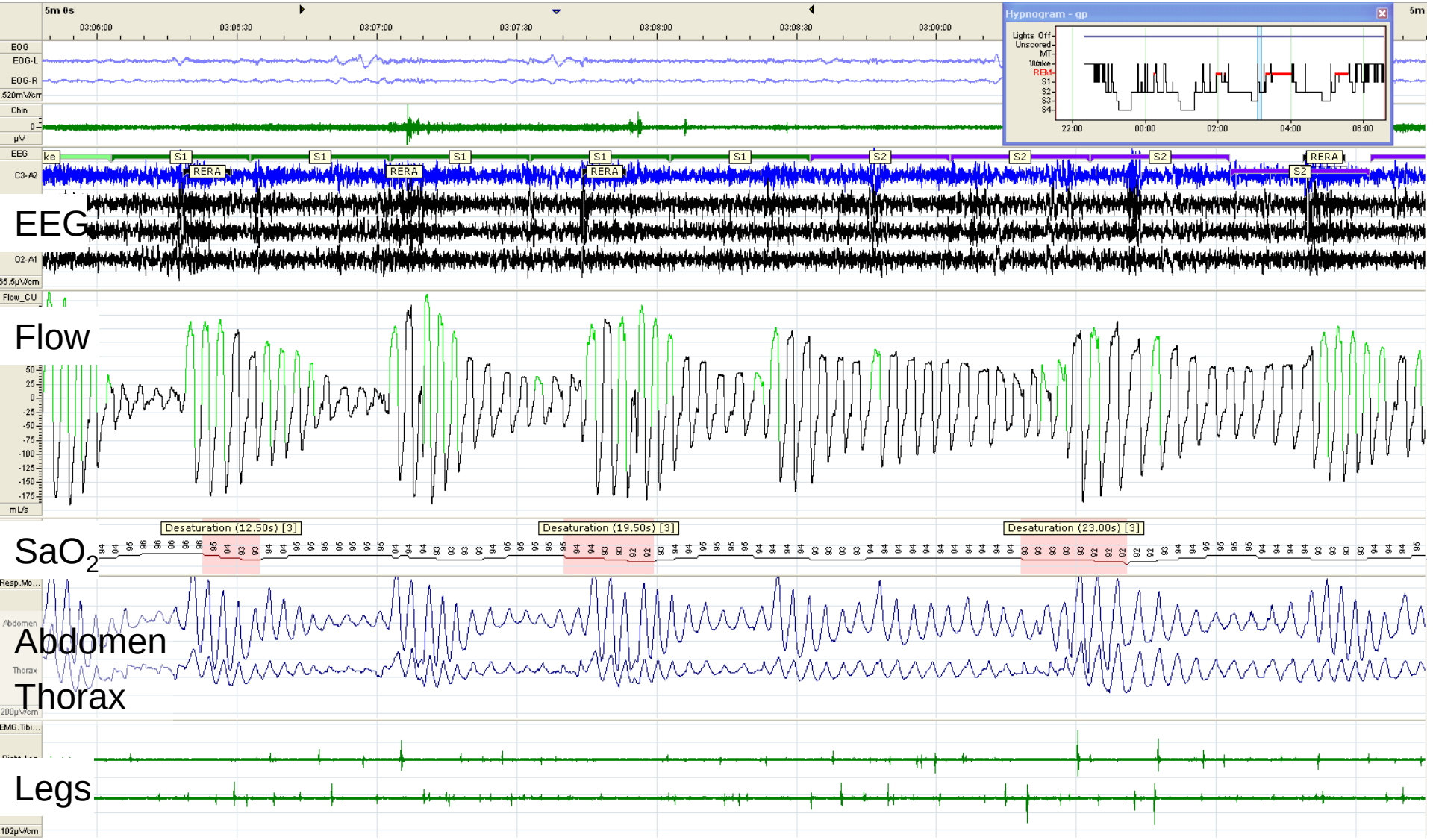
Berry et al. Journal of Clinical Sleep Medicine 2012;8:597-619



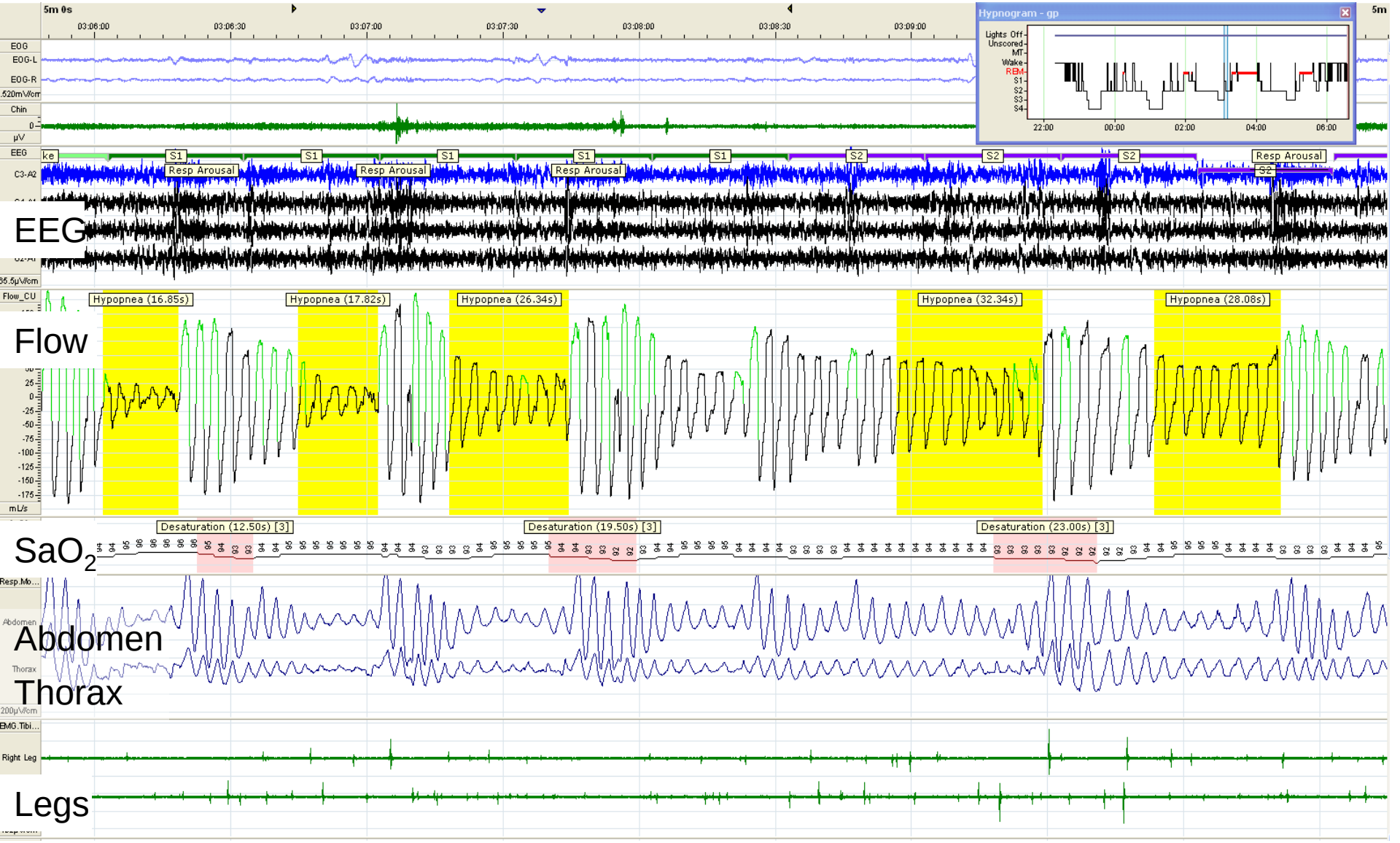
How many respiratory events do you see ?



According to **Chicago** (AASM 1999) criteria: <u>6 hypopneas</u>



According to AASM 2007 (recommended) criteria: 0 events



According to **AASM 2013** criteria: <u>5 hypopneas</u>

Apnea Rules for Adults

AASM 2013 update:

1. drop in peak signal excursion by **≥ 90%** of pre-event baseline using

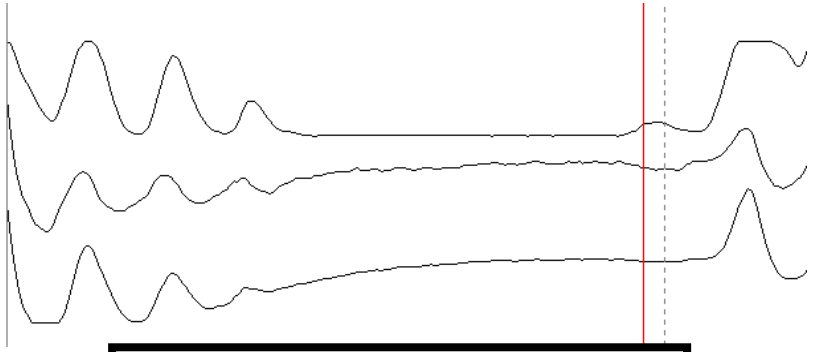
AND

2. duration of the ≥ 90% drop in sensor signal is **≥ 10 seconds**

If a portion of a respiratory event that would otherwise meet criteria for a hypopnea meets criteria for an apnea, the entire event should be scored as an apnea.

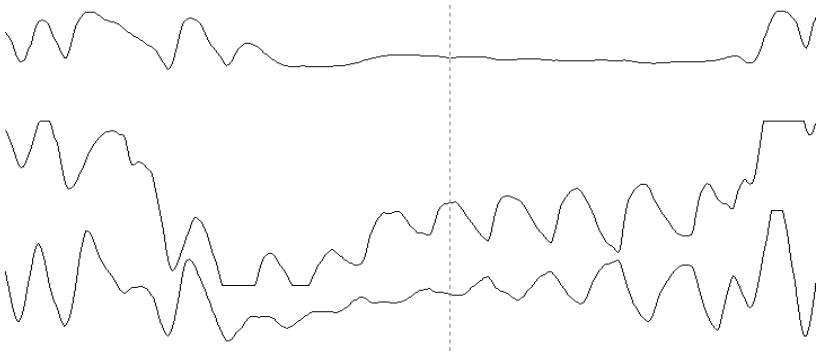
The definition does **NOT** require an associated arterial oxygen desaturation

Central apnea



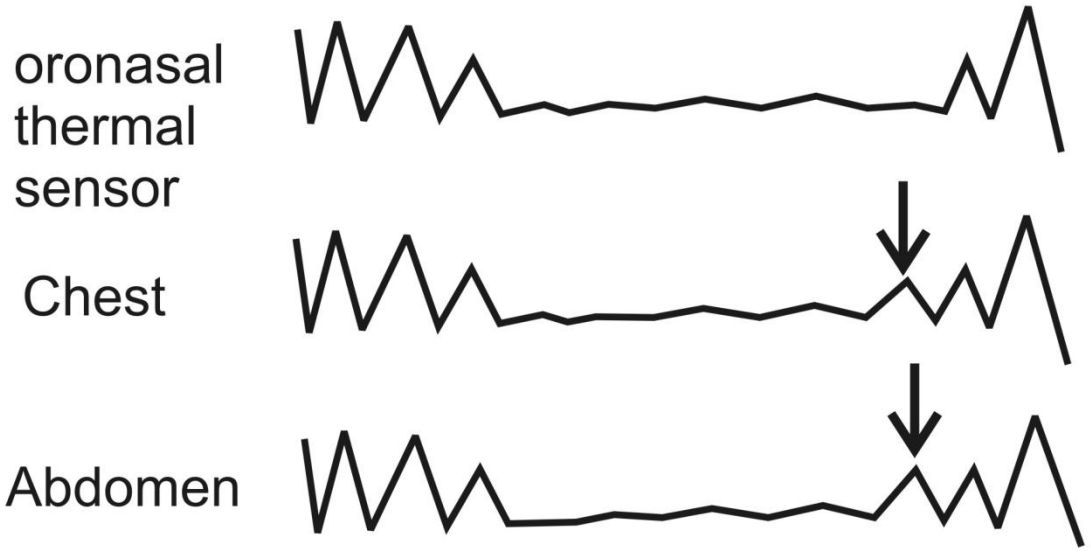
No airflow
No chest or abdominal movements

Obstructive apnea



No airflow
Presence of chest and abdominal efforts

Central vs Mixed apnea



1 obstructed breath at the end of apnea

Is this a mixed apnea?

Is this a central apnea?

Hypopnea Rules for Adults

AASM 2013 update:

1. Peak signal excursion drop by **≥ 30%** of pre-event baseline using nasal pressure / PAP device flow

2. Duration of this drop **≥ 10** seconds

3. There is a **≥ 3%** oxygen desaturation from pre-event baseline **OR** the event is associated with an **arousal**

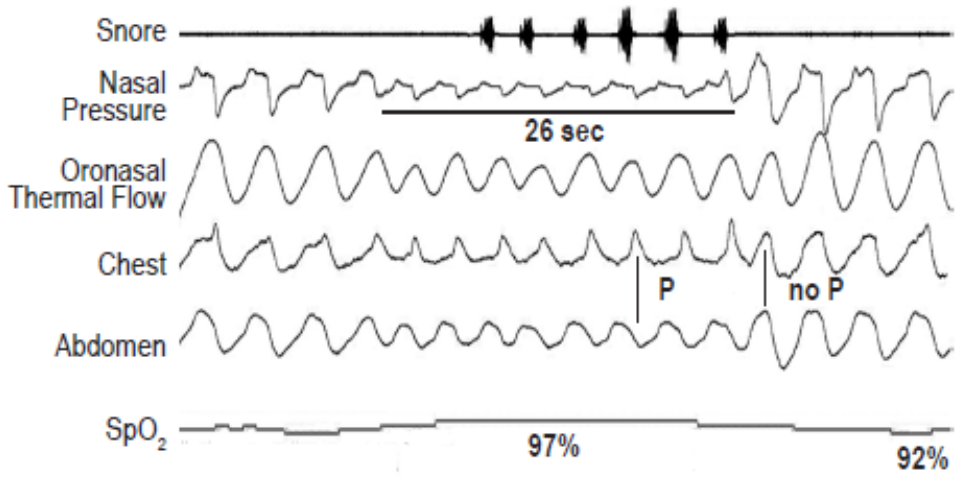
Differences between obstructive and central hypopnoeas

For an obstructive hypopnoea at least one of the following criteria must be met:

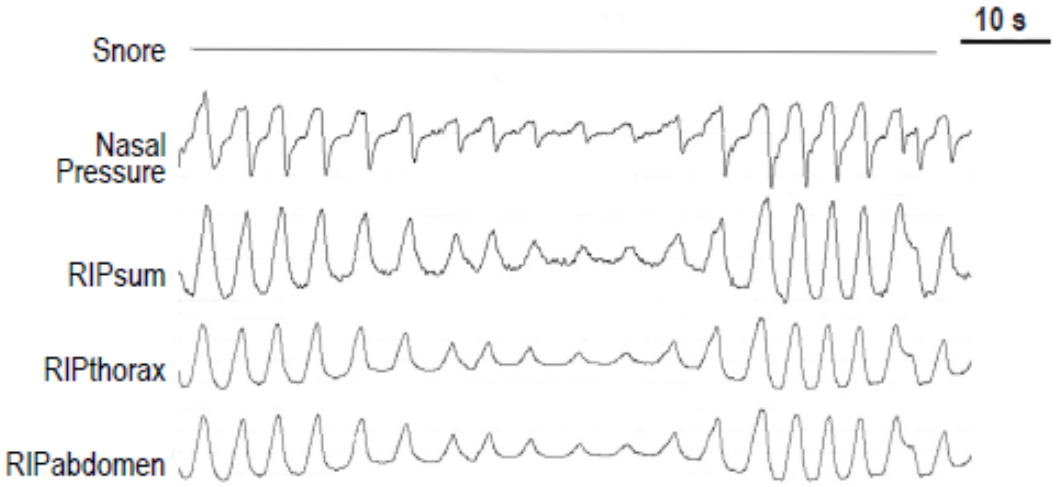
- Snoring during the event
- Increased inspiratory flattening of the nasal pressure device compared to baseline
- Thoracoabdominal paradox occurs during the event but not during pre-event breathing

For a central hypopnoea, none of these criteria must be present

Obstructive hypopnea

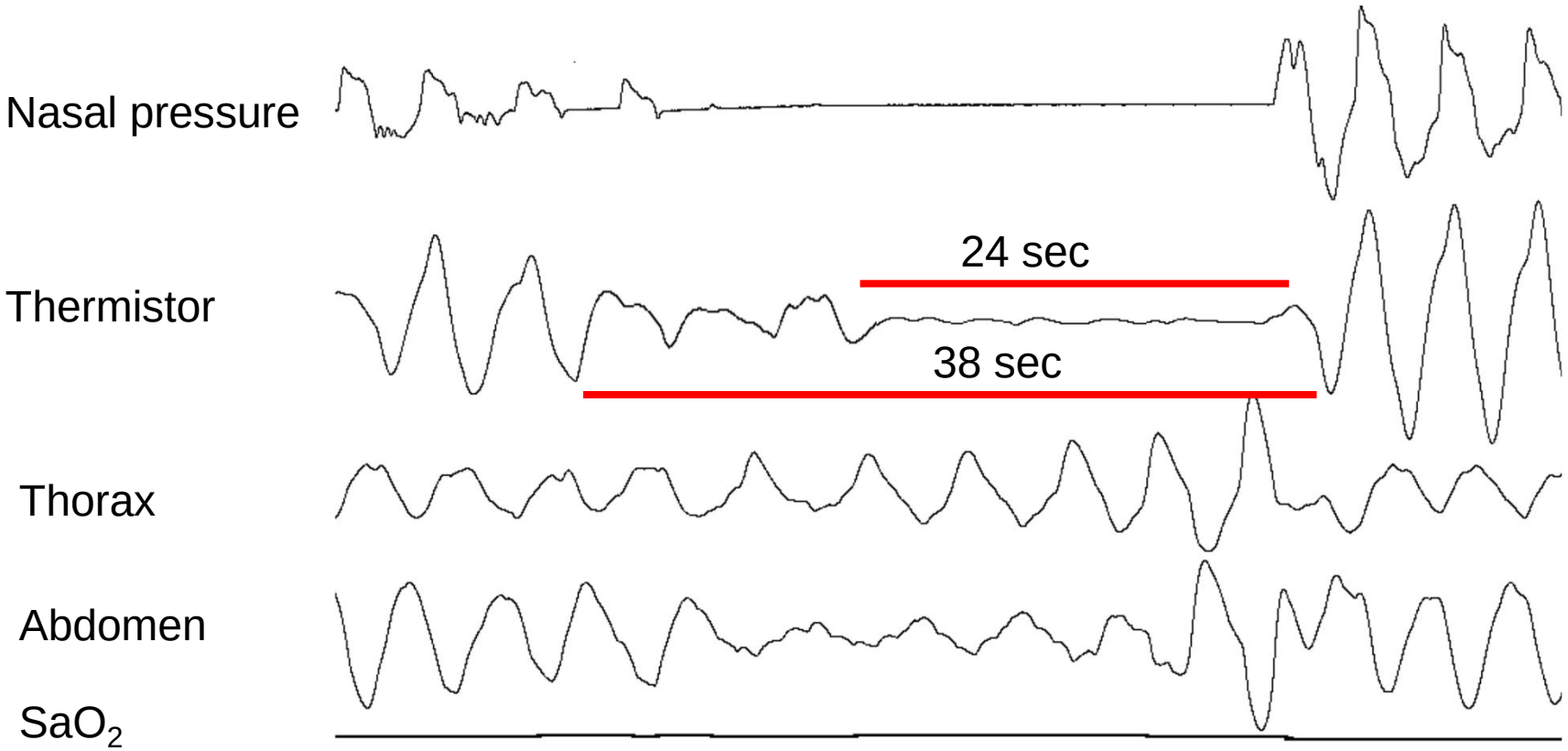


Central hypopnea



Respiratory event duration

This event should be scored as an apnea and its duration would be **38** seconds



Respiratory effort related arousals

RERA can be scored if

- There is a sequence of breaths lasting at least 10 seconds characterized by increasing respiratory effort (oesophageal pressure) or by flattening of the inspiratory portion of the nasal pressure leading to arousal

-The sequence of breaths does not meet criteria for an apnea or hypopnea.

- RERA index can be added to AHI to provide RDI (respiratory disturbance index)

Respiratory effort related arousals

EEG

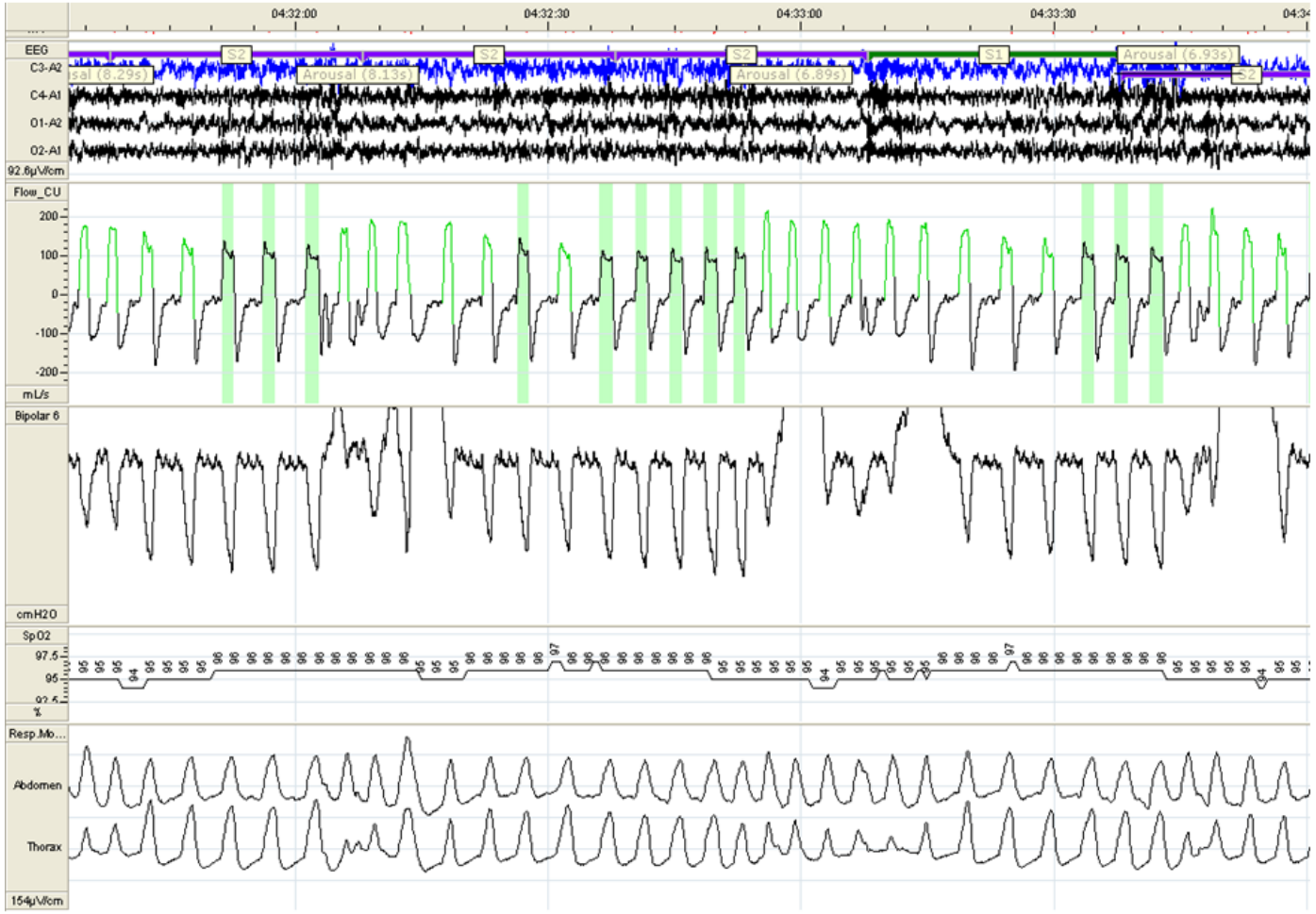
Nasal pressure

Oesophageal pressure

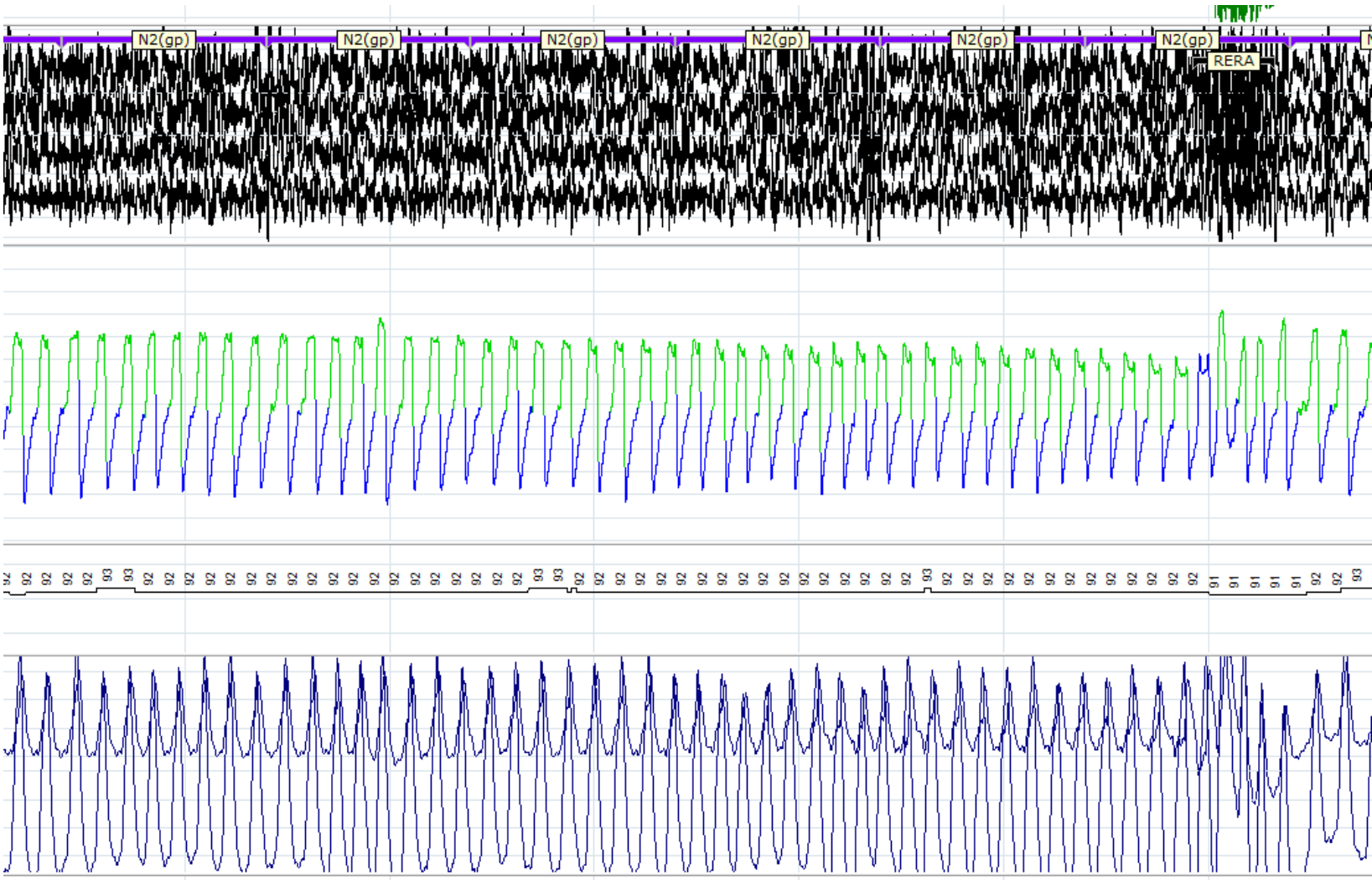
SaO_2

Thorax

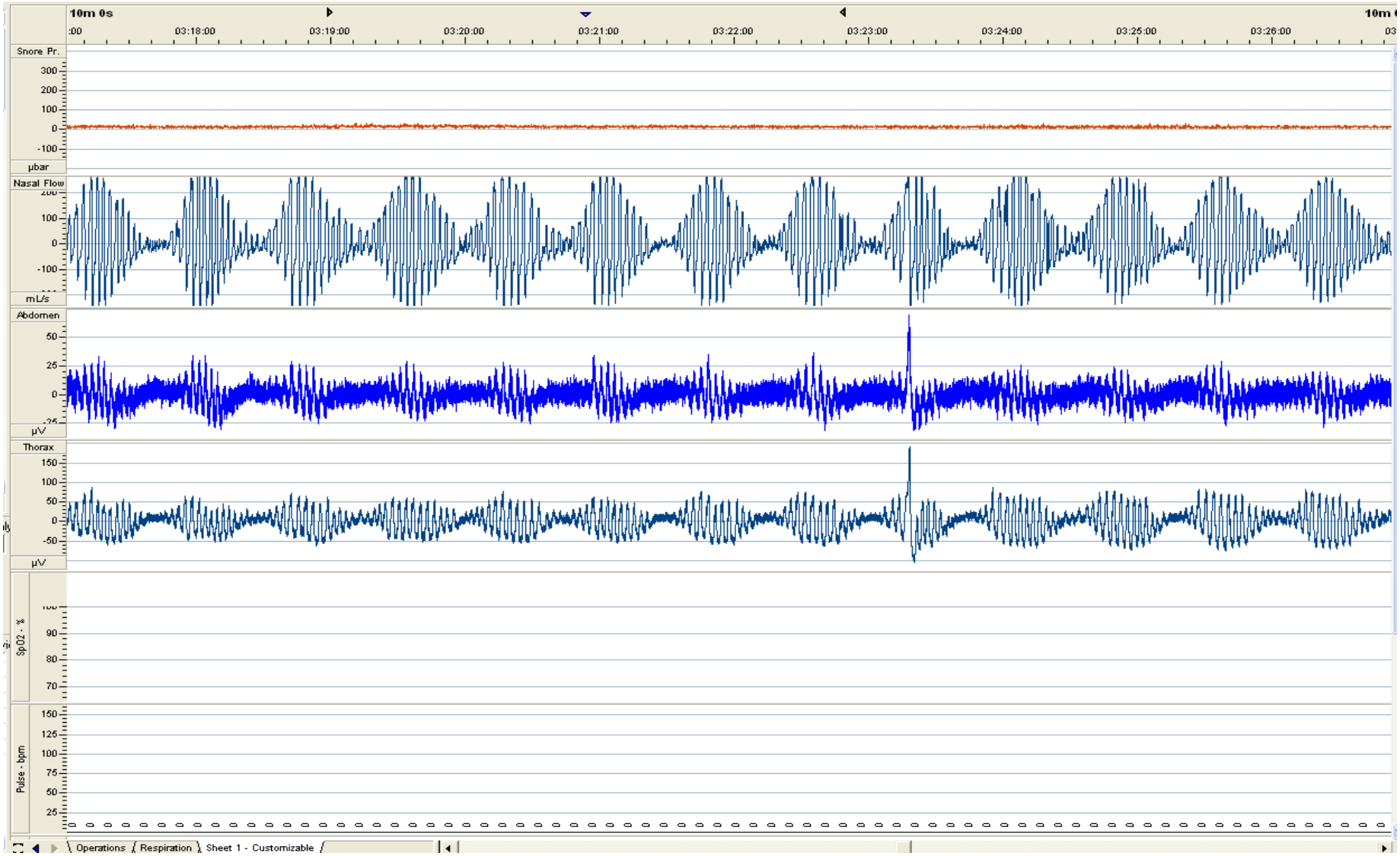
Abdomen



Respiratory effort related arousals



Cheyne-Stokes Respiration



Cheyne-Stokes Respiration in Civil Engineering

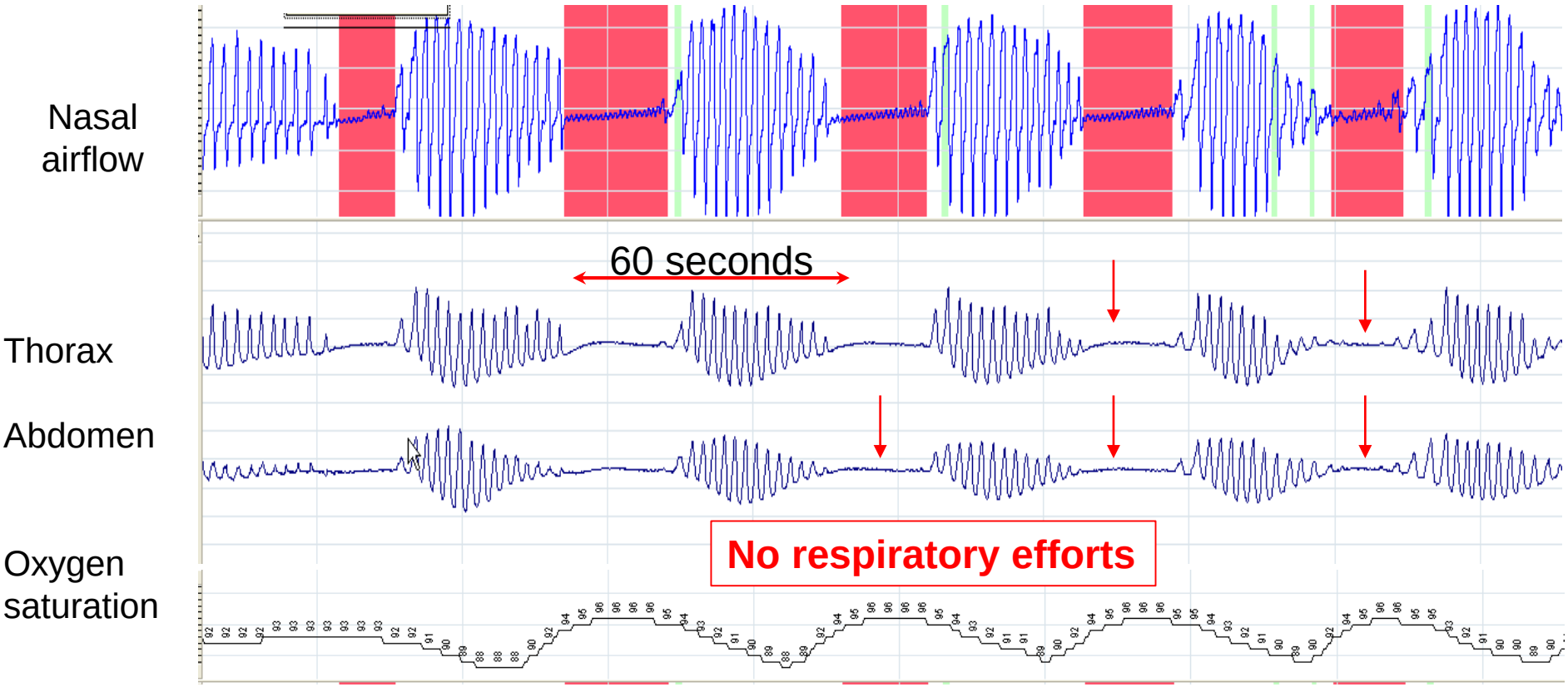
Cheyne-Stokes Breathing Rule for Adults (AASM 2013)

1. There are episodes of at least 3 consecutive central apneas and/or central hypopneas separated by a crescendo and decrescendo change in breathing amplitude with a cycle length of at least 40 seconds (typically 45 to 90 seconds).

2. There are 5 or more central apneas and/or central hypopneas per hour associated with the crescendo/decrescendobreathing pattern recorded over a minimum of 2 hours of monitoring.

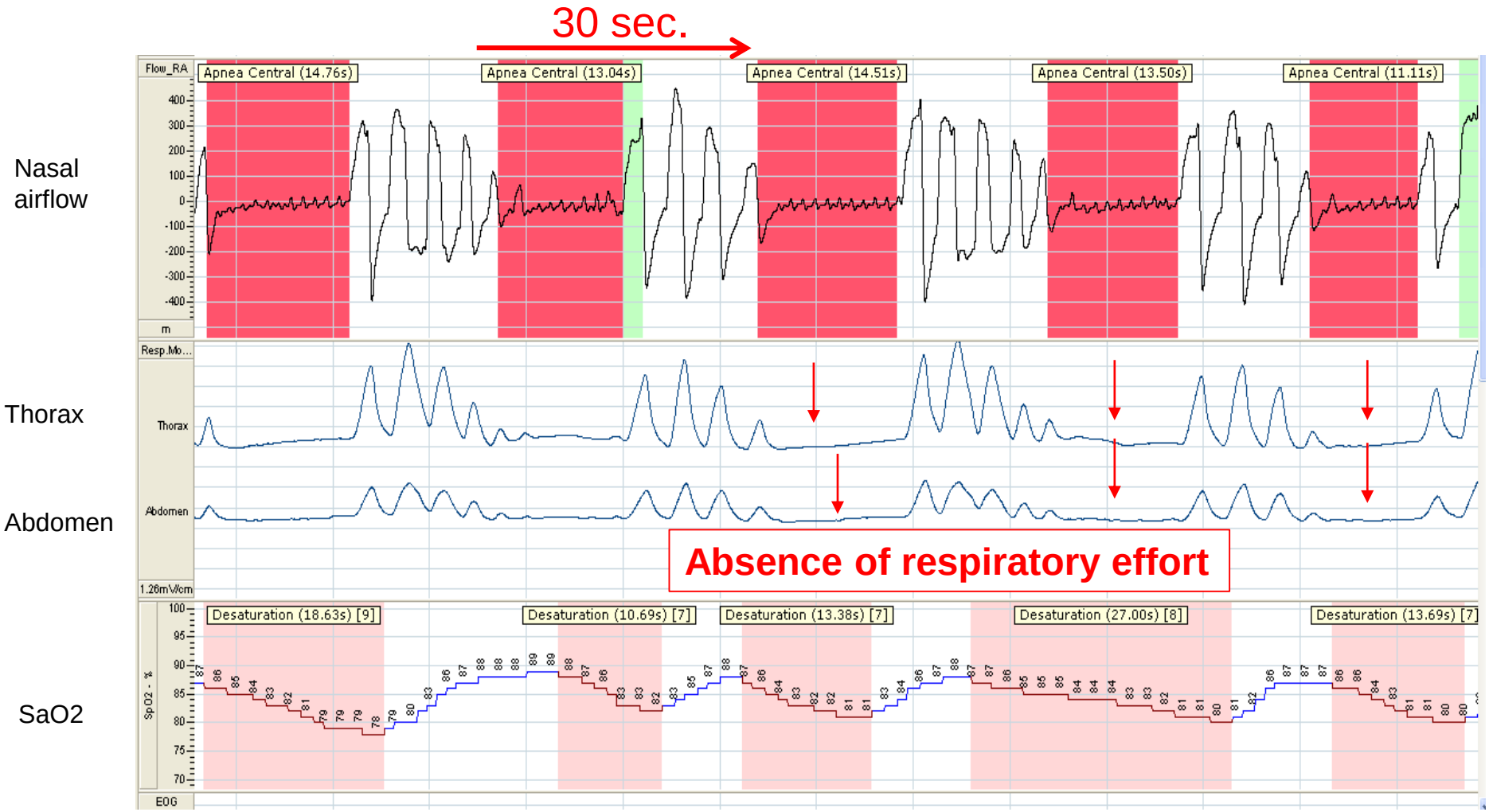
Note: The duration of CSB (absolute or as a percentage of total sleep time) or the number of CSB events should be presented in the study report.

Cheyne stokes breathing



Typically seen in patients with heart failure and low left ventricular ejection fraction

Idiopathic or altitude-induced central apneas



Recording of a young mountaineer in Ladakh (3200 m).The main difference with cheyne stokes is the shorter cycle length and the absence of crescendo-decrescendo

Respiratory polygraphy

Since there are no official scoring rules for polygraphy, the PSG AASM criteria are commonly used for PG

Problems:

-No EEG to determine arousals as scoring criterion for hypopnea

- Total sleep time (to calculate AHI) has to be estimated based on patients' report or surrogate variables (movements etc…)

PG vs PSG

- **PG can <u>underestimate</u> the AHI**

- Total recording time (PG) is always greater than total sleep time (denominator of the AHI)

- Arousals cannot be detected on PG (less hypopnea can be scored)

- **PG can <u>overestimate</u> the AHI**

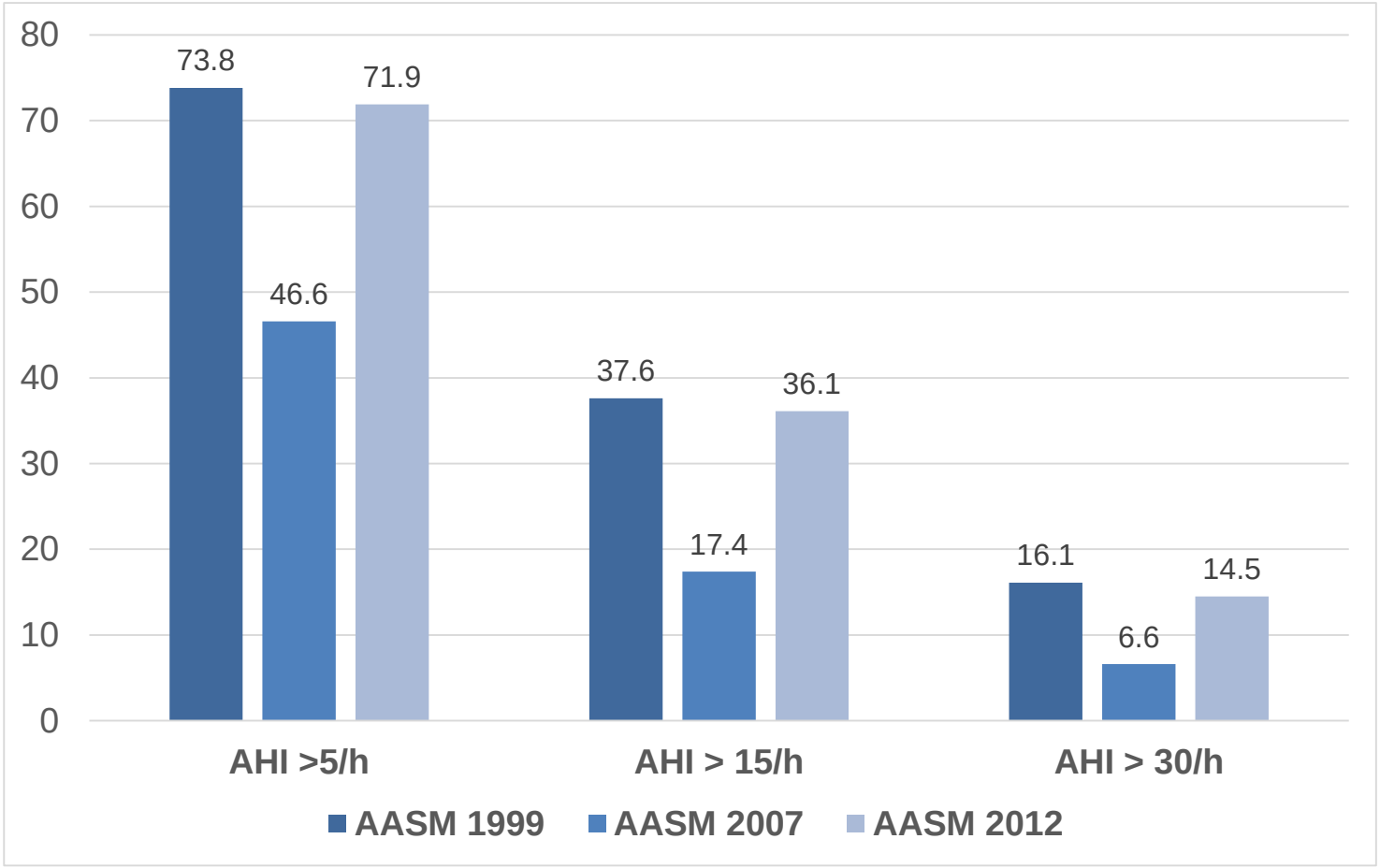
- Respiratory events can be scored during wake time PG recordings (no EEG)

Normal values for adult sleep studies and polygraphy

Official apnea-hypopnea index (AHI) severity classification

Normal	<5/h
Mild	5-15/h
Moderate	15-30/h
Severe	>30/h

Prevalence of SDB according to different AHI thresholds in the general population



N= 2162 PSG

HypnoLaus sleep cohort 2015

Problems and open questions

1. Should these « official » thresholds be used with all scoring criteria and new recording techniques ?

2. Should the same AHI thresholds be used for a 20 years old woman and an 80 years old man ?

3. Can the same AHI reference values be used for polygraphy and polysomnography ?

Cave: The AHI should not be taken as a positive/negative value but should be seen as a continuum and integrated in the clinical picture of the patient

Indications for treatment for sleep disordered breathing in adults

1. Daytime sleepiness associated with sleep disordered breathing (SDB)

   a. Other causes of sleepiness should be excluded (sleep curtailment etc …)
   b. There is no direct correlation between AHI and sleepiness severity
   c. If there is no improvement in daytime sleepiness with SDB treatment, other causes should be investigated (narcolepsy, idiopathic hypersomnia, depression …)

2. Severe SDB in presence of cardiovascular disease or important CV risk factors

   a. The observed blood pressure reduction with CPAP is modest (2-3 mmHg)
   b. The protective effect of SDB treatment as secondary prevention for stroke or heart infarct is still debated

Case-based discussion

Case 1

- Man 82 years old
- Heavy snorer
- Witnessed apneas during sleep by bed partner
- Epworth 5/24, no daytime complaints
- Blood pressure 158/90

- Polysomnography: AHI 35/h, obstructive

Shall we recommend treatment ?

Case 2

- Man 35 years old

- Heavy snorer
- Epworth 13/24, no obvious cause for sleepiness
- No cardiovascular risk factors or comobidities

- Polygraphy: AHI 9/h, obstructive hypopnea + flow limitations

What would be the next step ?

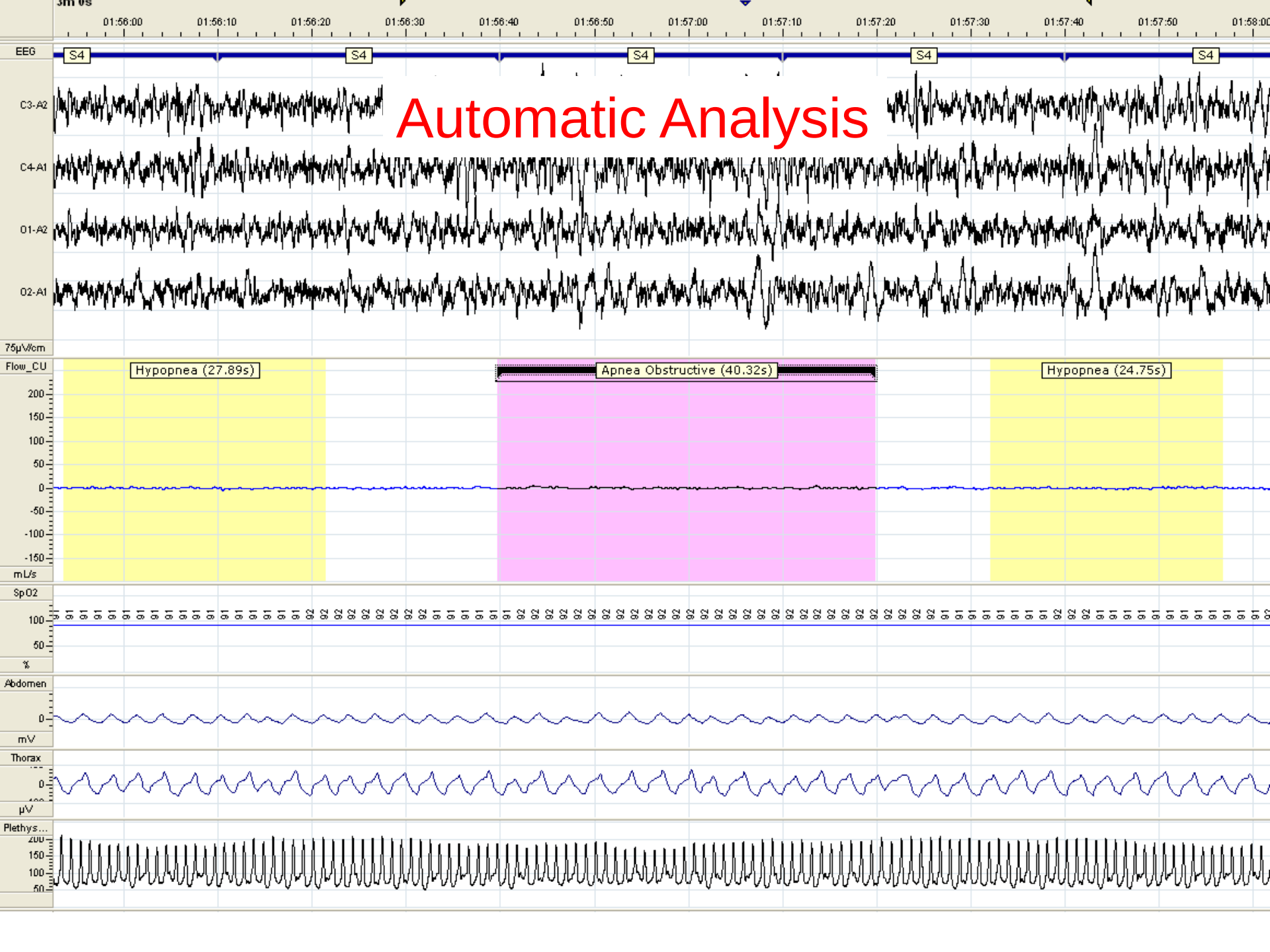
Case 3

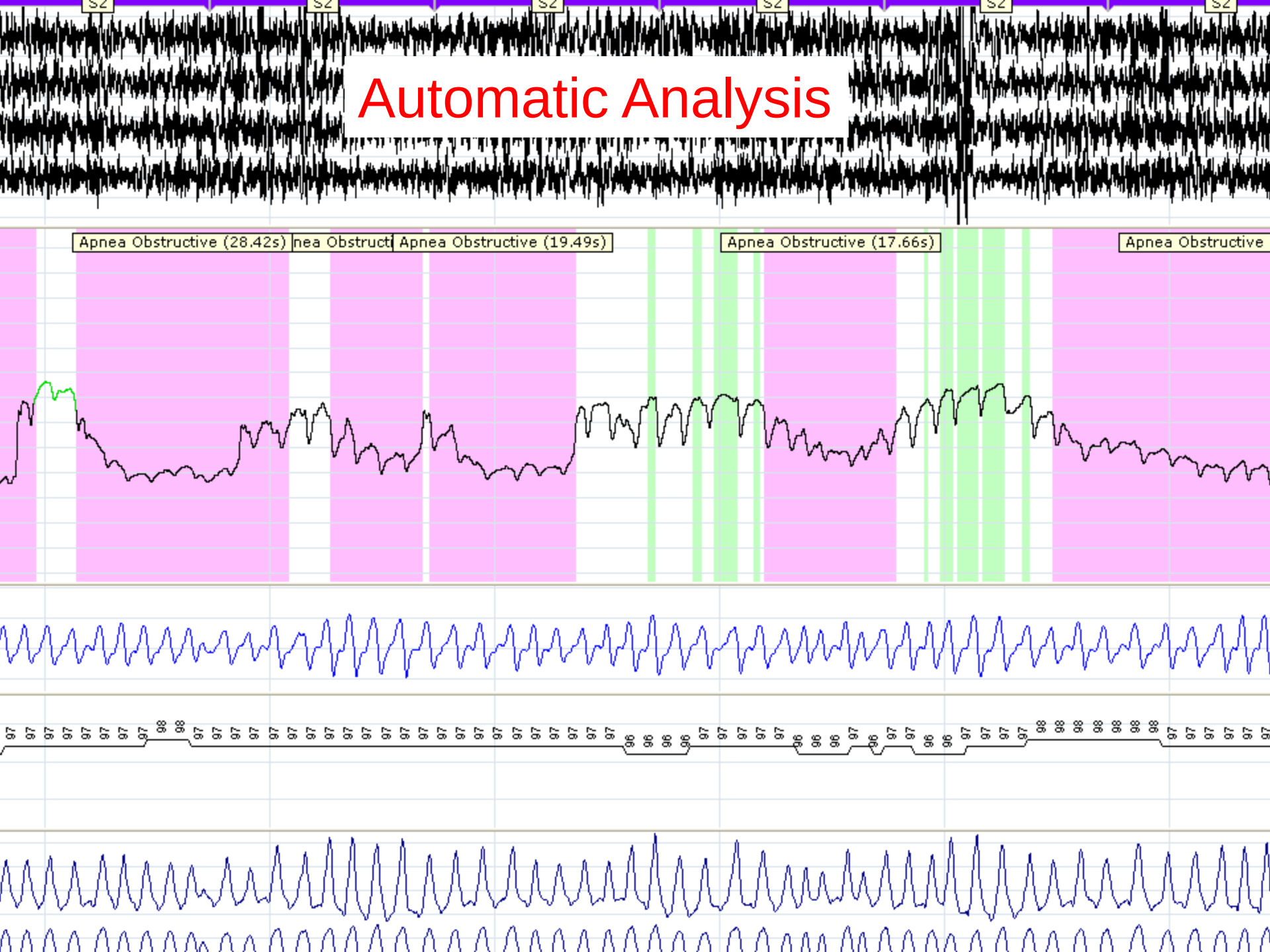
- Woman 35 years old

- Occasional snorer
- Epworth 9/24
- Recently diagnosed with depression
- Polygraphy: AHI 22/h, obstructive hypopneas

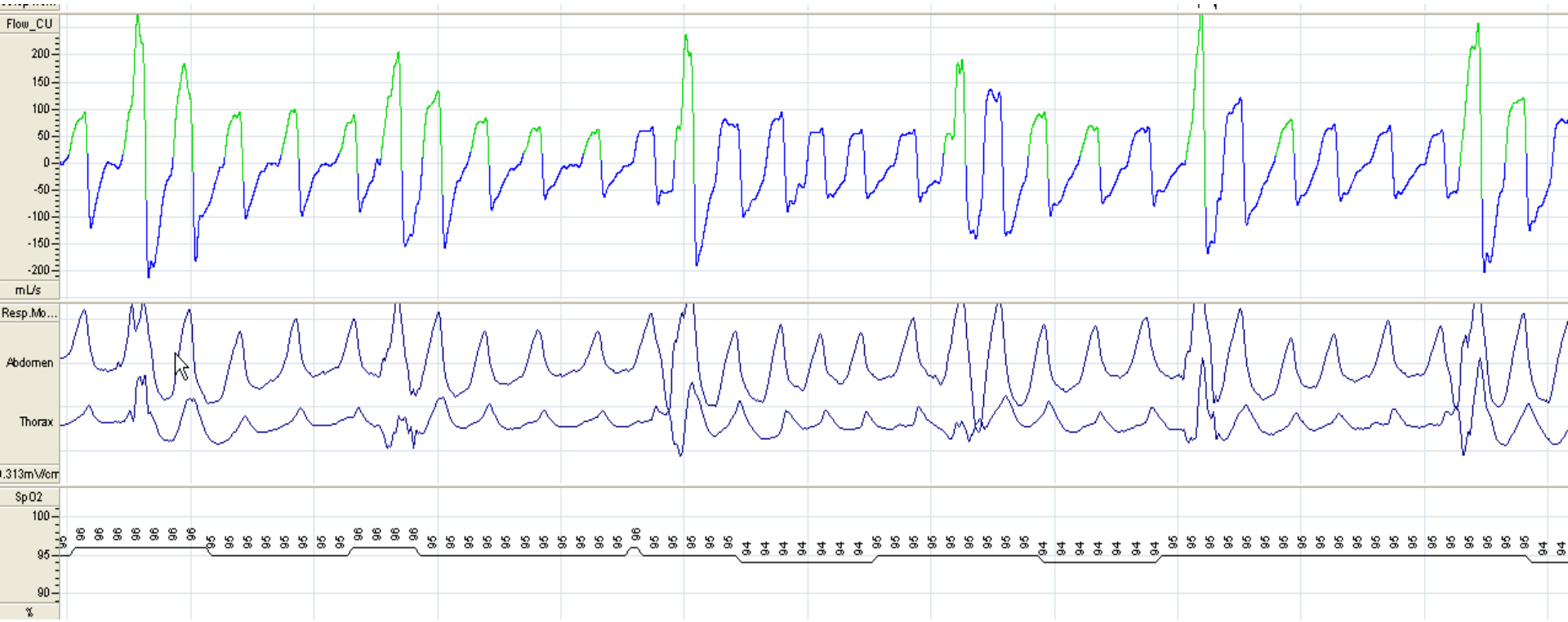
Shall we recommend a treatment ?

Respiratory polygraphy pitfalls


3m 0s
01:56:00
01:56:10
01:56:20
01:56:30
01:56:40
01:56:50
01:57:00
01:57:10
01:57:20
01:57:30
01:57:40
01:57:50
01:58:00
EEG
S4
S4
S4
S4
S4
C3-A2
C4-A1
O1-A2
O2-A1
Automatic Analysis
75µV/cm
Flow_CU
Hypopnea (27.89s)
Apnea Obstructive (40.32s)
Hypopnea (24.75s)
200
150
100
50
0
-50
-100
-150
mL/s
SpO2
100
50
%
Abdomen
0
mV
Thorax
0
µV
Plethys...
200
150
100
50

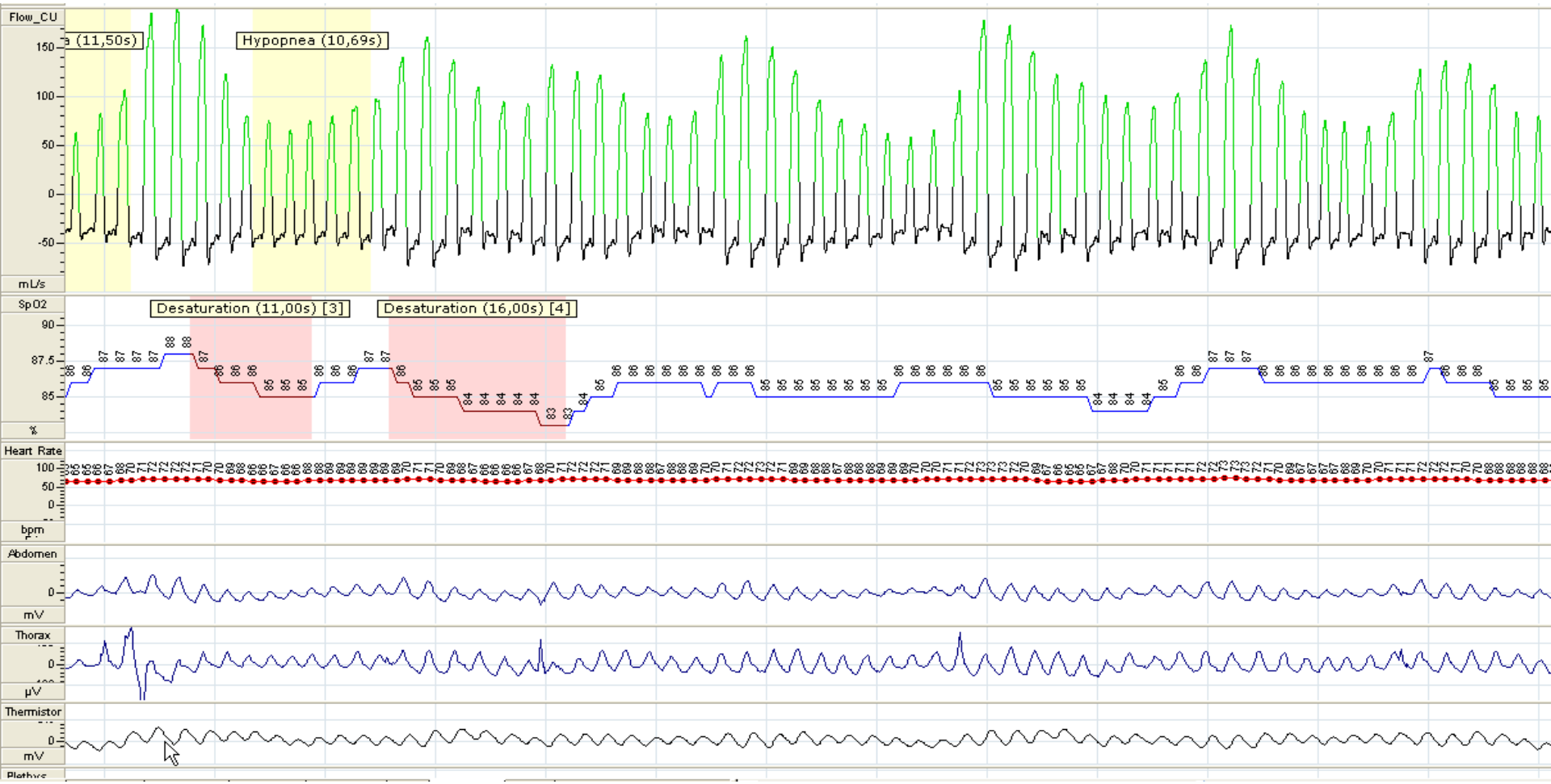

Automatic Analysis
Apnea Obstructive (28.42s)
nea Obstructi
Apnea Obstructive (19.49s)
Apnea Obstructive (17.66s)
Apnea Obstructive

How would you score these events on polygraphy?

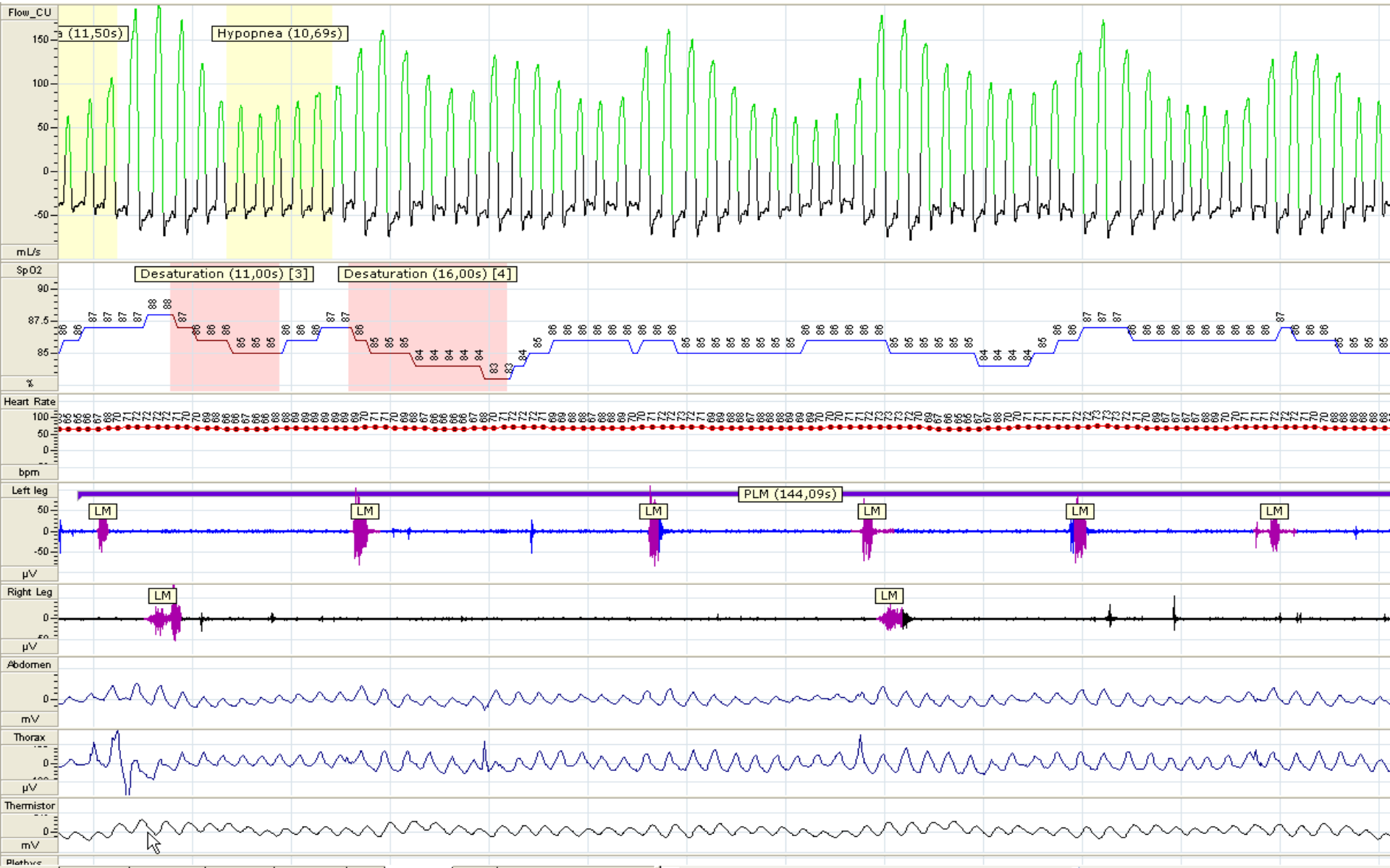



22:52:00
22:52:10
22:52:20
22:52:30
22:52:40
22:52:50
22:53:00
22:53:10
22:53:20
22:53:30
22:53:40
22:53:50
22:54:00
EEG
S2
PLM Arousal
C3-A2
C4-A1
O1-A2
O2-A1
66.5µV/cm
Flow_CU
200
150
100
50
0
-50
-100
-150
-200
mL/s
Resp.Mo...
Abdomen
Thorax
Periodic legs movement-induced breathing instability
SpO2
100
95
90
%
Left leg
LM
PLM (3m 15s)
µV
Snore_CU
0.25

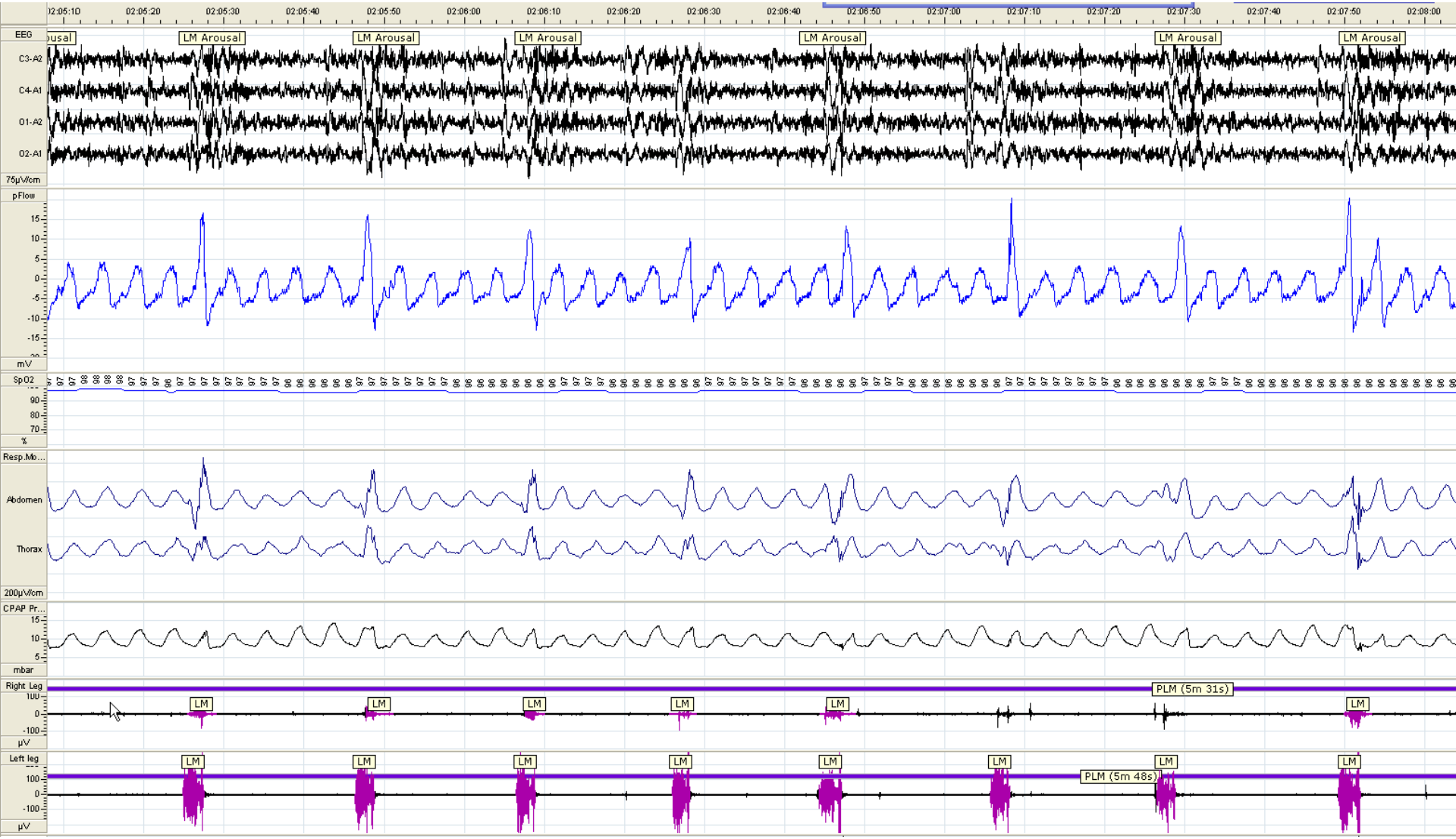
Hypopneas or not ?



Periodic limb movements during sleep



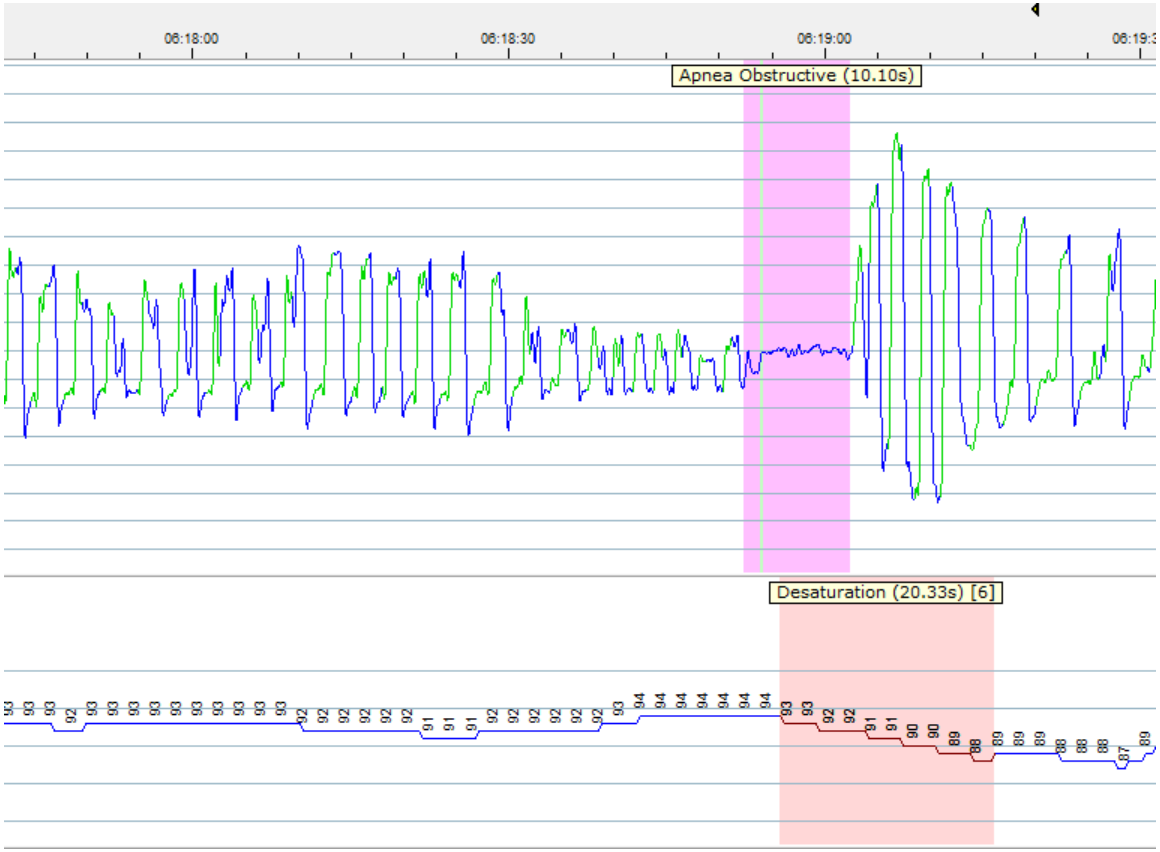
Automatic PG report: AHI 50/h



Apnea or hypopnea ?

Nasal pressure

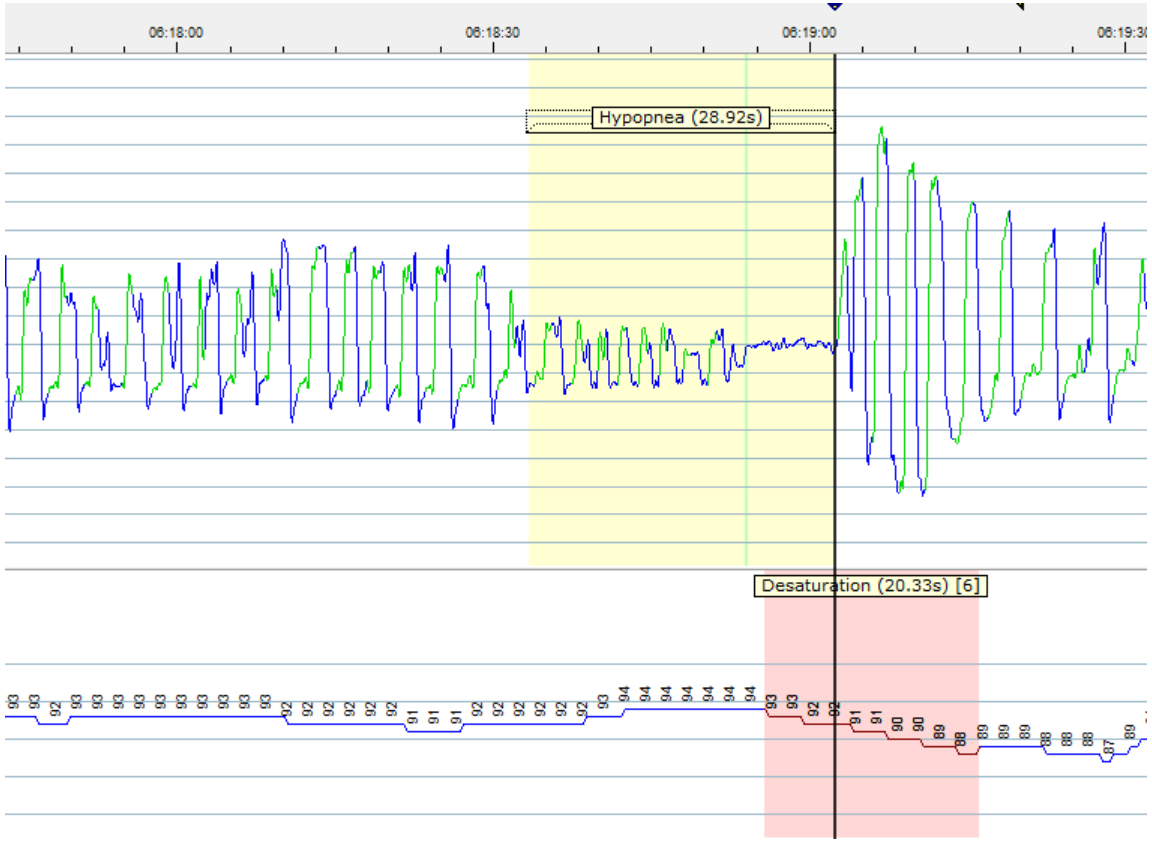
SaO2



Apnea or hypopnea ?

Nasal pressure

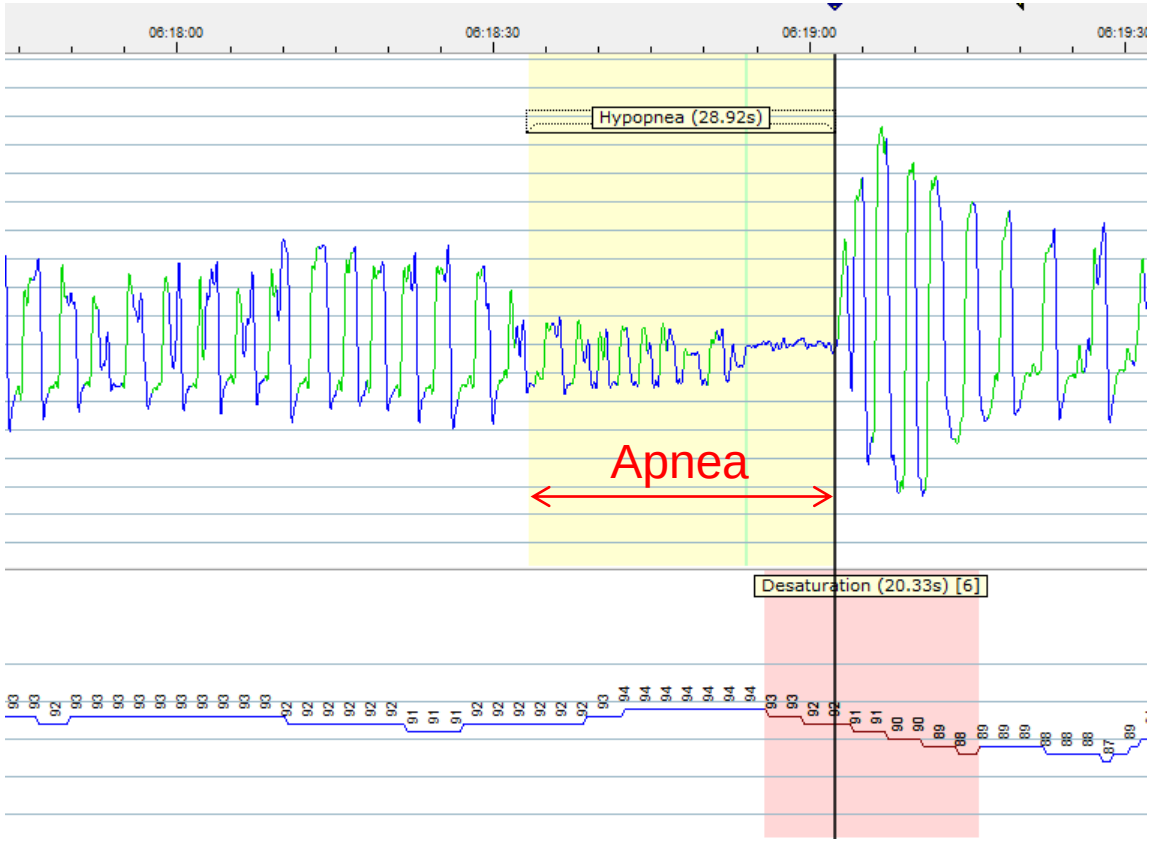
SaO2



Apnea or hypopnea ?

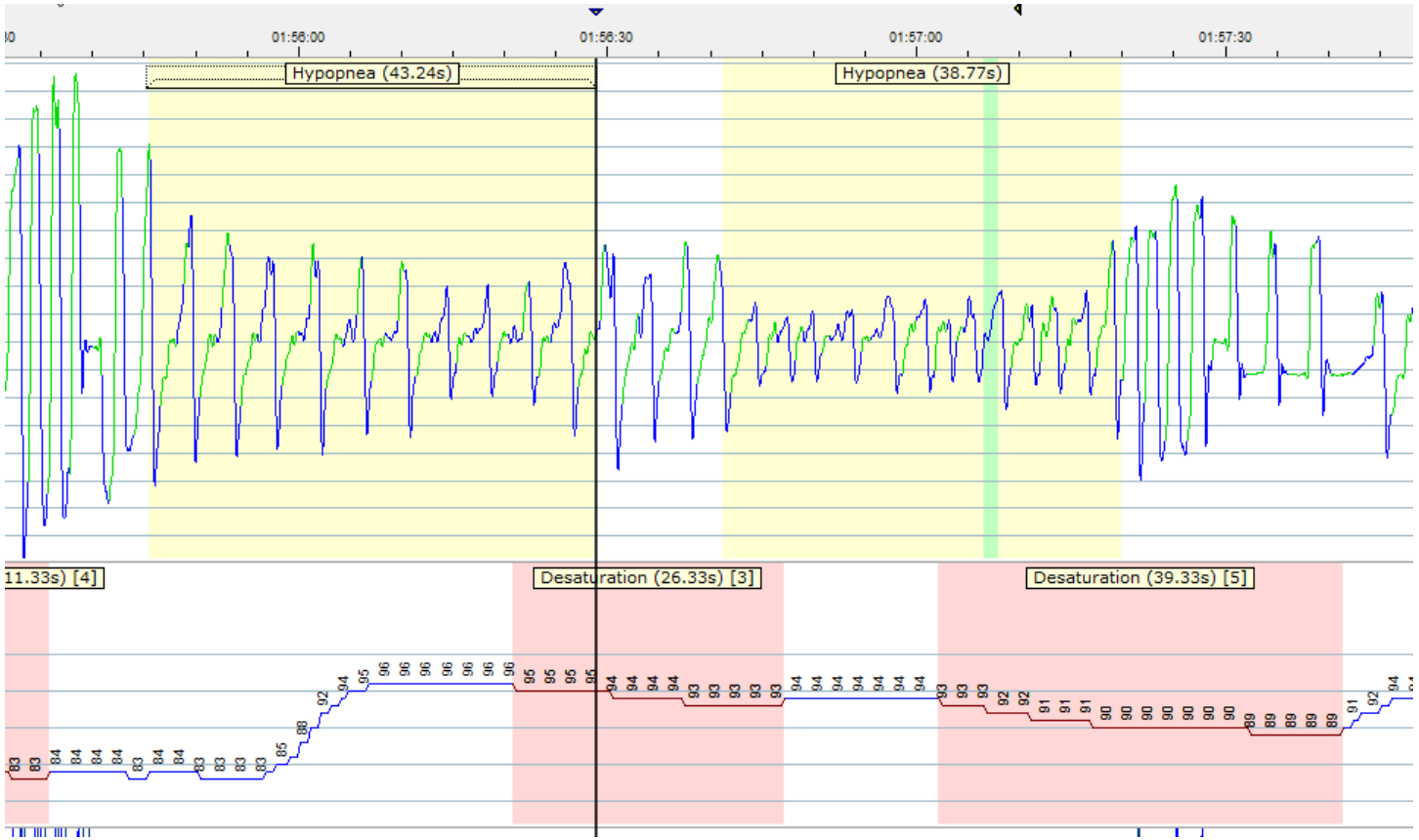
Nasal pressure

SaO2



According to AASM 2013 rule, the whole event should be scored as 28 sec apnea

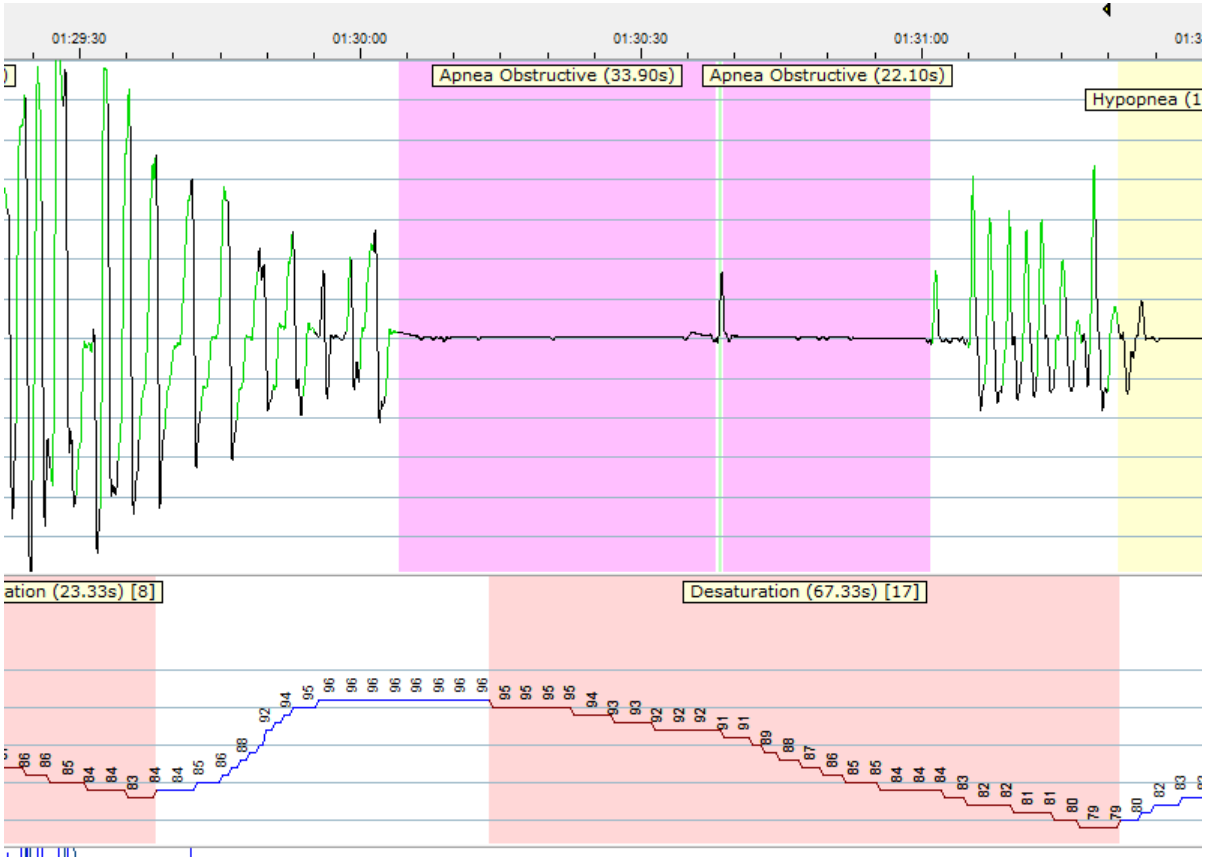
1 or 2 hypopnea (s) ?



1 or 2 apnea (s) ?

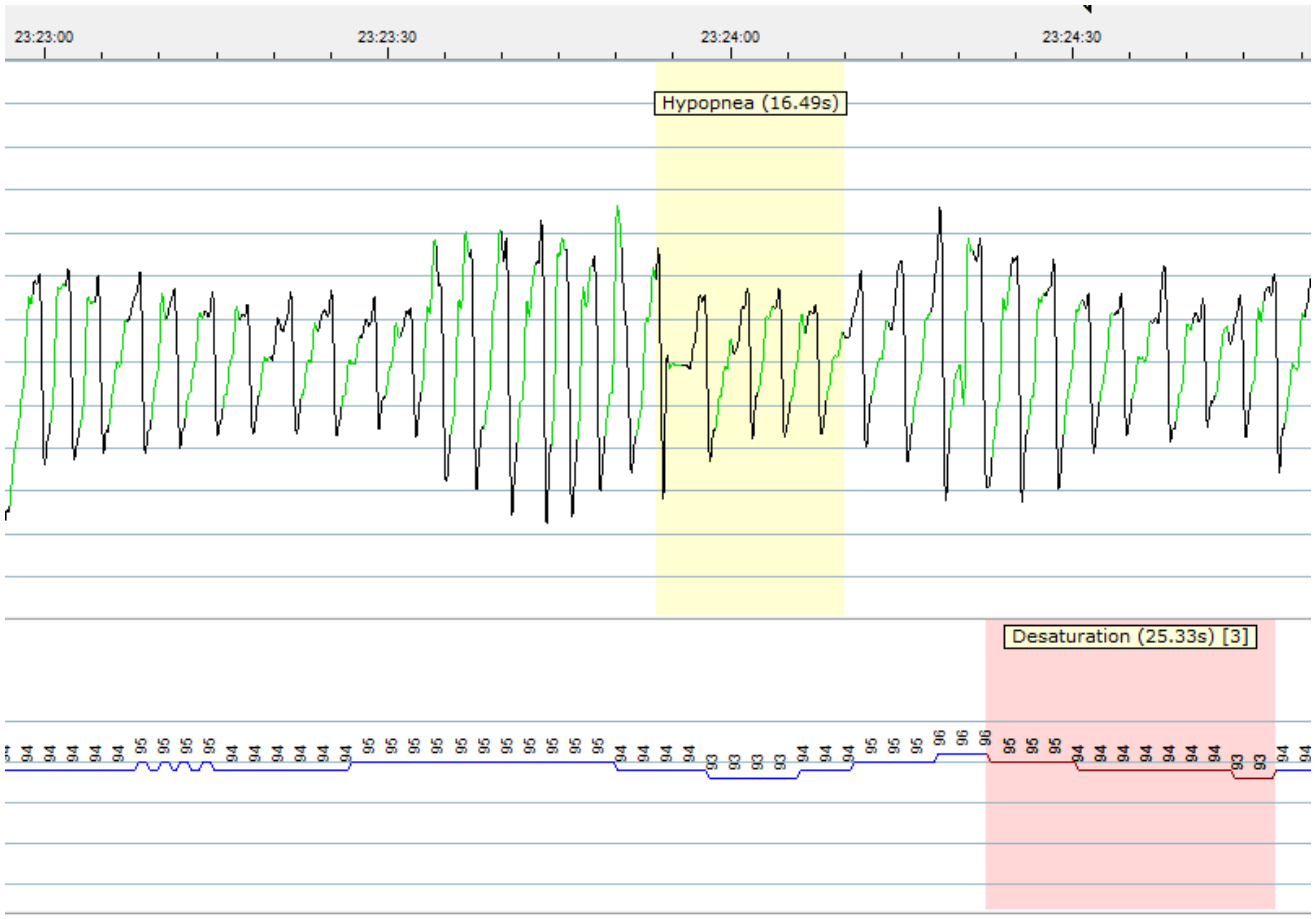
Nasal pressure

SaO2

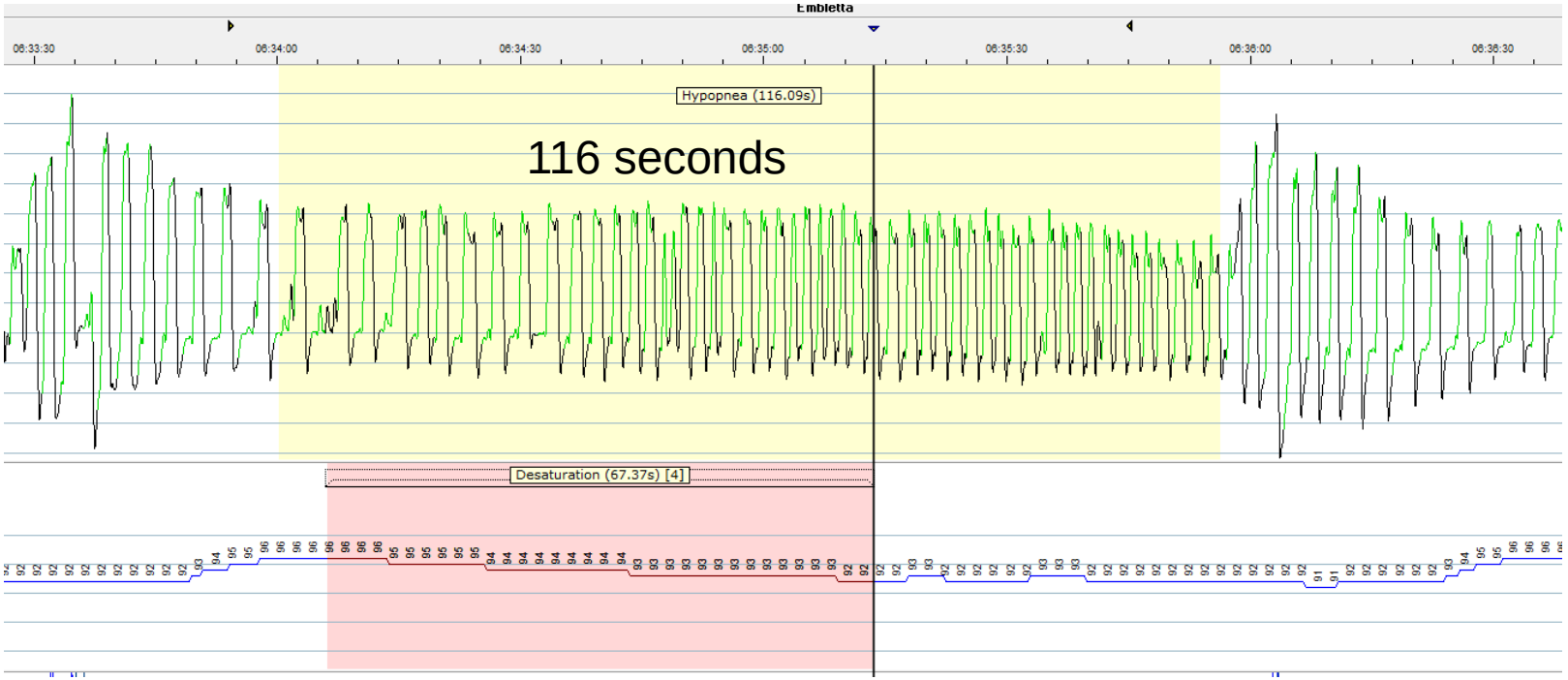


Baseline for SpO2 ? Baseline for nasal pressure ?

Baseline for SaO2 ? Baseline for nasal pressure ?



Is this a hypopnea ?



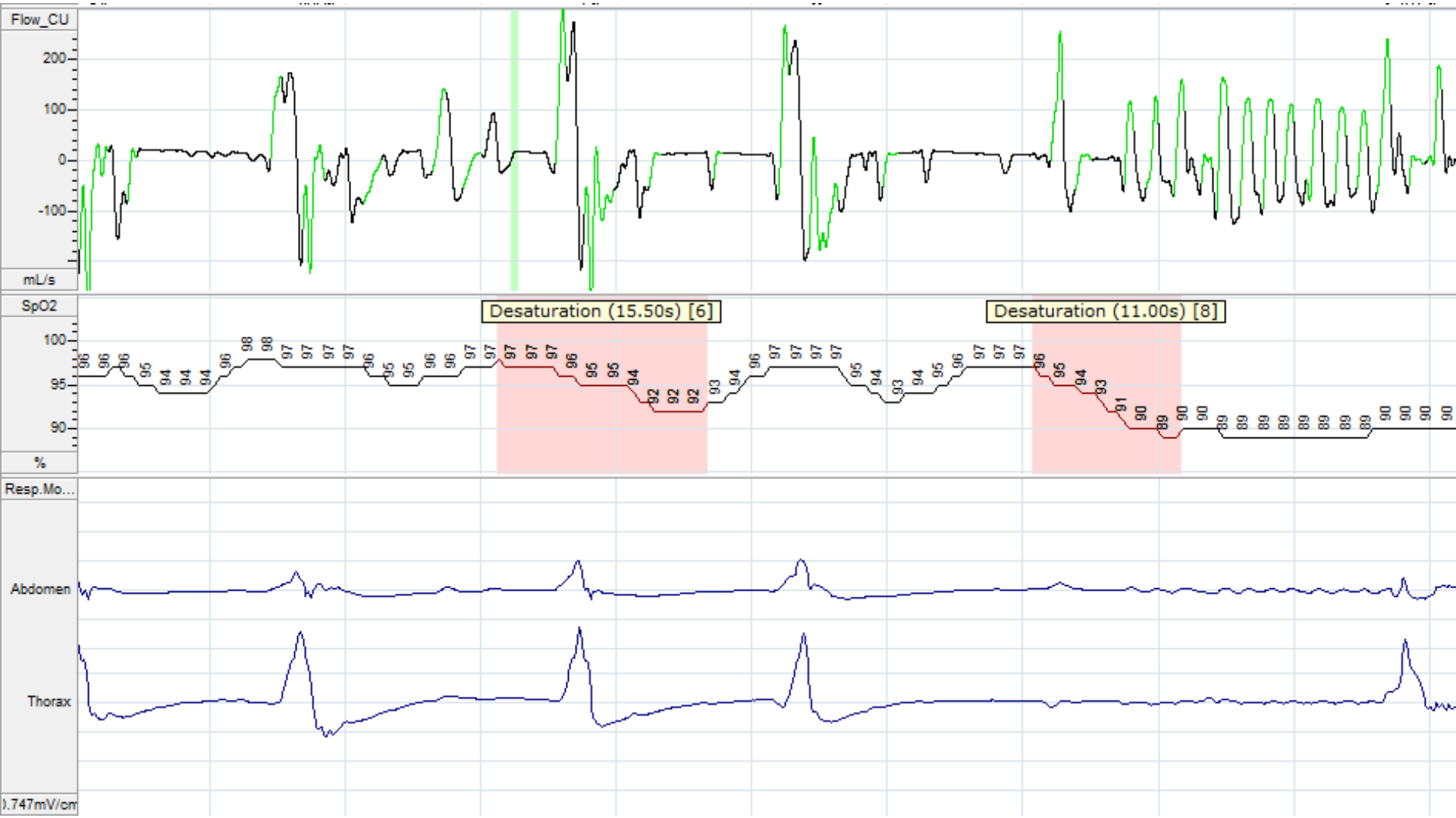
67 seconds

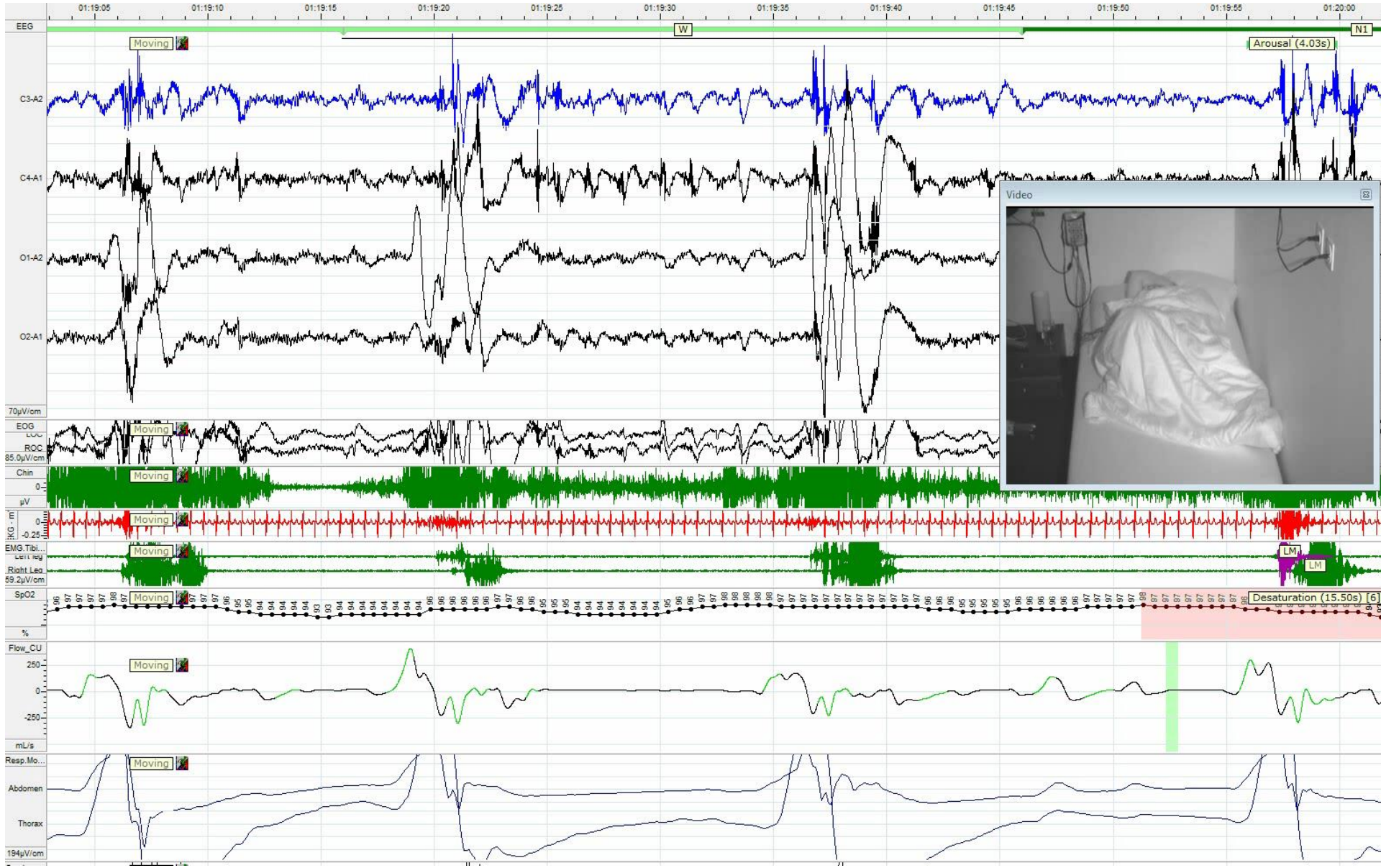
Should there be a maximal duration for hypopnea ?

Is this a hypopnea ?

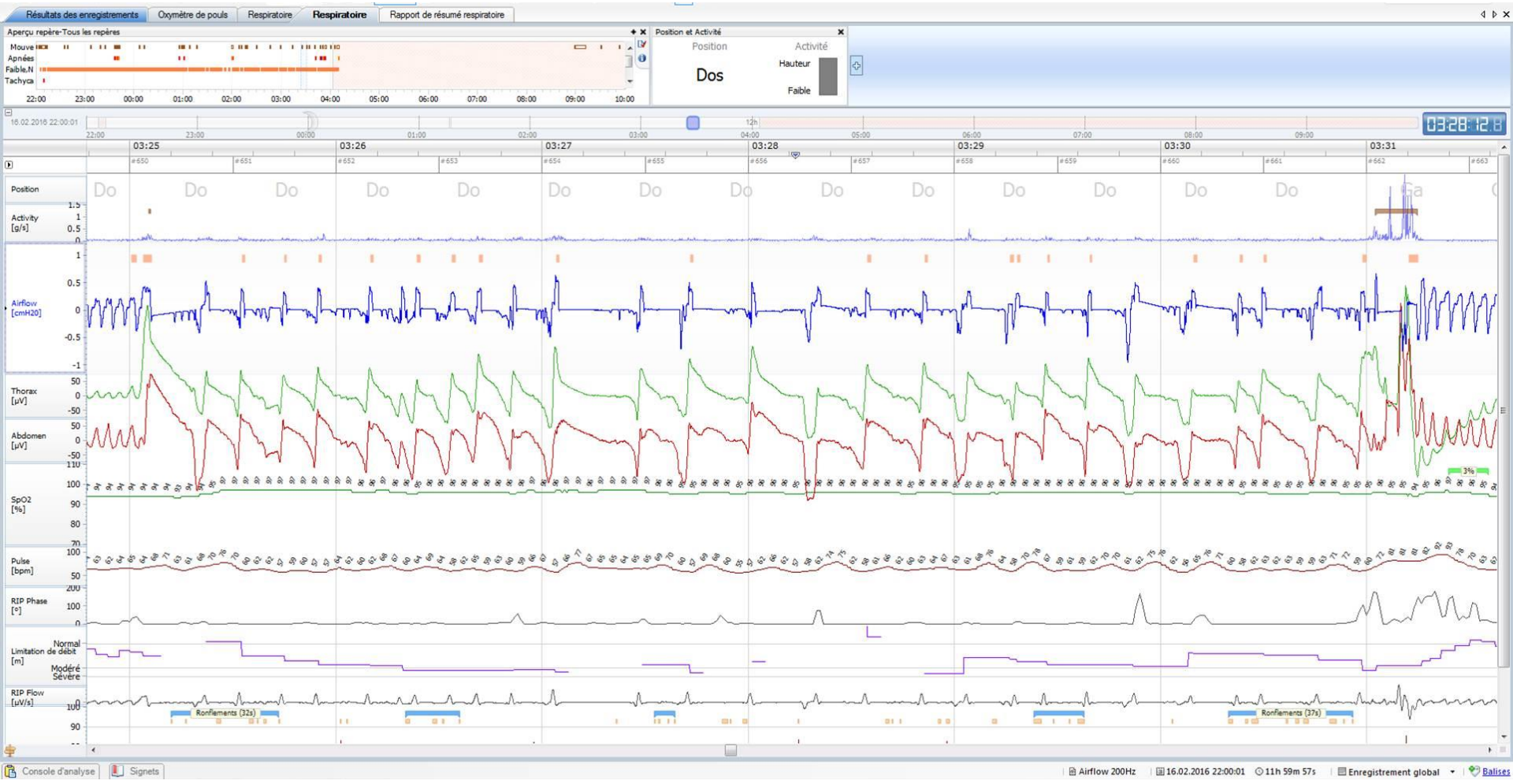
Should there be a maximal duration for hypopnea ?

How would you score these events on polygraphy ?




01:19:05
01:19:10
01:19:15
01:19:20
01:19:25
01:19:30
01:19:35
01:19:40
01:19:45
01:19:50
01:19:55
01:20:00
EEG
W
N1
Moving
Arousal (4.03s)
C3-A2
C4-A1
O1-A2
O2-A1
70µV/cm
EOG
ROC
85.0µV/cm
Chin
µV
EKG - m
-0.25
EMG.Tibi...
Left Leg
Right Leg
59.2µV/cm
LM
SpO2
%
Desaturation (15.50s) [6]
Flow_CU
250
0
-250
mL/s
Resp.Mo...
Abdomen
Thorax
194µV/cm
Video

What is this ?



Courtesy Dr N. Petitpierre


00:01:18:16

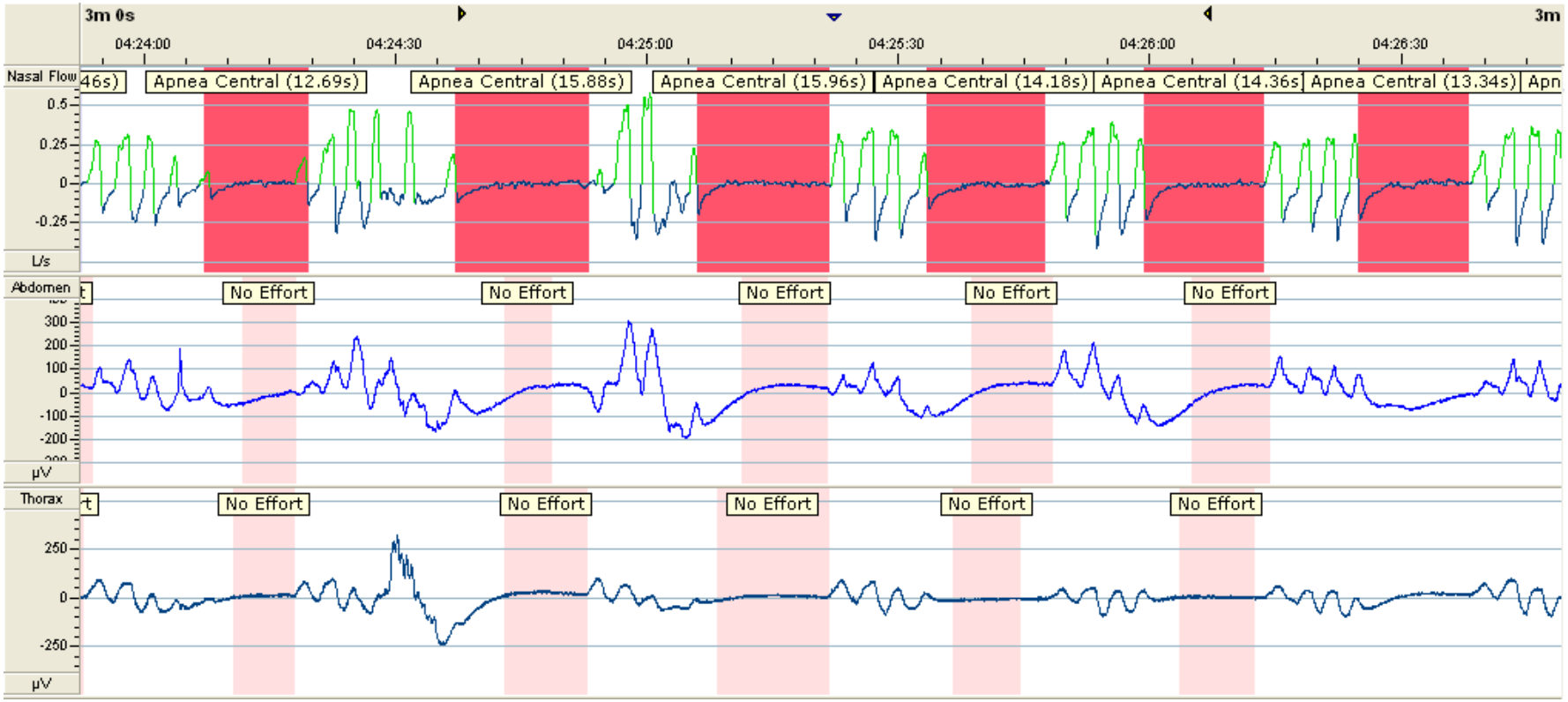
Central Sleep Apnoea

- Apnoea associated with a lack of respiratory effort (>10 seconds)

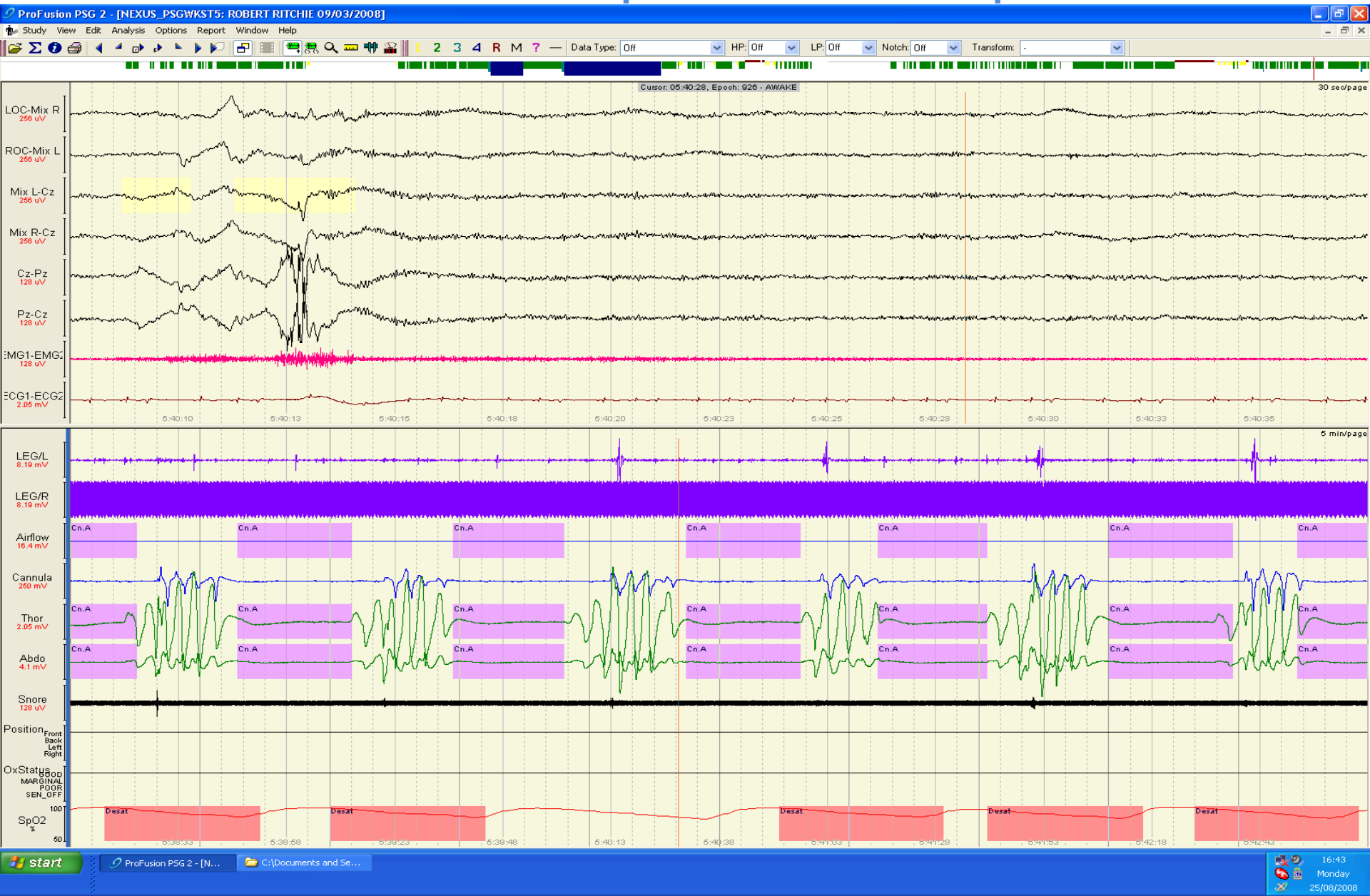
- Diagnosed on PSG
  - primary diagnosis if >=50% of apnoeas are scored as central

- CSA and OSA may co exist

Central apnoea?



Screen capture N2 Sleep



Messages

- ✓ **<u>Never</u> trust automatic scoring**
- ✓ **Always perform visual analysis and beware of atypical cases**
- ✓ **PLMS can induce breathing instability, CPAP does not detect PLMS which may lead to false pressure increases**
- ✓ **Cough, talking, sneezing, catathrenia can look like apnea or hypopnea**