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# Principles of Amplitude Integrated EEG (aEEG) & Basic Trace Pattern Qualifications

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# Objectives

Upon completion of this program, the clinician will be able to:

- Describe aEEG trending components including filtering, compression, rectification
- Describe aEEG trace nomenclature and qualifications as they pertain to term babies and premature babies at various gestational ages
- Assess aEEG trace patterns and apply trace nomenclature/qualifications to define aEEG background patterns
- Assess aEEG trace patterns and apply trace qualifications for areas of suspicion/suspected seizures
- Describe how artifact and/or impedance may impact trace purity

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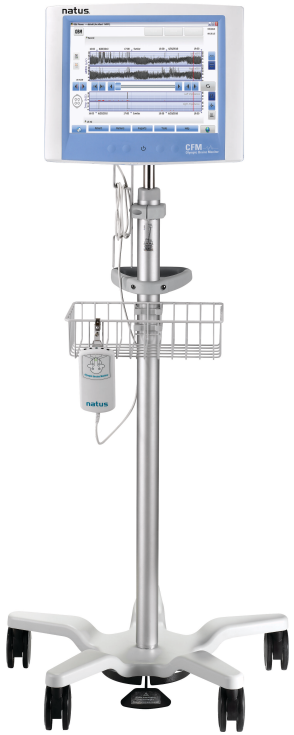
# What is aEEG?

- aEEG is:
  - 1, 2, or 3 channel bedside brain *monitor*
  - Basic neurologic function trending tool
  - Long-term monitoring capability
  - Used to measure global electro-cortical activity or specific site brain activity
  - Developed by Neonatologists, for Neonatologists
  - <u>Complimentary</u> tool to <u>*quickly*</u> obtain information regarding the baby's neurological status



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# Monitoring Tools in the NICU

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# What Do We Want to Know When We Monitor the Brain with aEEG?

- **What is the neurological status of the patient?**
  - Is there cerebral injury?
  - What is the severity of the injury?
  - What changes are occurring over time?
    - Is there improvement or worsening of the neurological status
  - What is the impact of NICU treatments to the patient's brain function?
- **Is the patient having seizures?**
  - What is causing the seizures?
  - Are the seizures occurring more frequently, or for longer/shorter duration?
  - Are the seizures responding to medical therapy?
    - Is there electromechanical disassociation after medication?

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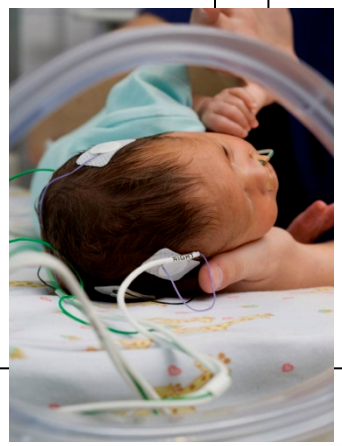
# Who Should Be Monitored? | Clinical Applications

- **Infants that have experienced a sentinel event during delivery and are at risk for hypoxic ischemic encephalopathy (HIE):**
  - Low Apgar
  - Low pH
  - Required resuscitation or artificial ventilation at birth
  - Poor tone/poor reflexes
- **Infants receiving hypothermia treatment for HIE**
- **Infants with definite or questionable seizures (clinical or subclinical):**
- **Infants with unexplained neurological symptoms (i.e. severe apnea)**

*Thoresen M, Hellstrom-Westas L, Liu X, de Vries L. "Effect of Hypothermia on Amplitude-Integrated Electroencephalogram in Infants With Asphyxia". *Pediatrics* published online June 21, 2010; DOI: 10.1542/peds.2009-2938



- **Infants who are at higher risk for cerebral complications due to circulatory instability**
  - Sepsis
  - Hypoxia
  - Persistent pulmonary hypertension
  - Meconium aspiration
  - Cardiac malformations
  - Diaphragmatic hernia
- **Additional clinical applications**
  - Muscle relaxed/neuromuscular blockade
  - Grade 3 or 4 IVH
  - ELBW infants
  - Inborn errors of metabolism (e.g. urea cycle disorders, hypoglycemia, hypocalcemia)
  - Neonatal abstinence syndrome (e.g. alcohol/ opiate withdrawal)
  - Post surgical
  - Post cardiac arrest
  - Infants requiring ECMO or surgery for CHD

NeoReviews Vol 7 No. 2
February 2006
**Hellstrom-Westas, Rosen, deVries, Greisen**

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# Breakdown - How Does aEEG Work?

- **aEEG ("a"=amplitude integrated / EEG = electroencephalography):**
  - One, two, or three channels of EEG that go through a number of modifications:
    - special filtering
    - rectification
    - compression
    - very slow, trend display
  - aEEG is a process of taking a raw EEG, modifying it, and producing a trending pattern that allows clinicians to measure and view the microvoltage of the brain over time

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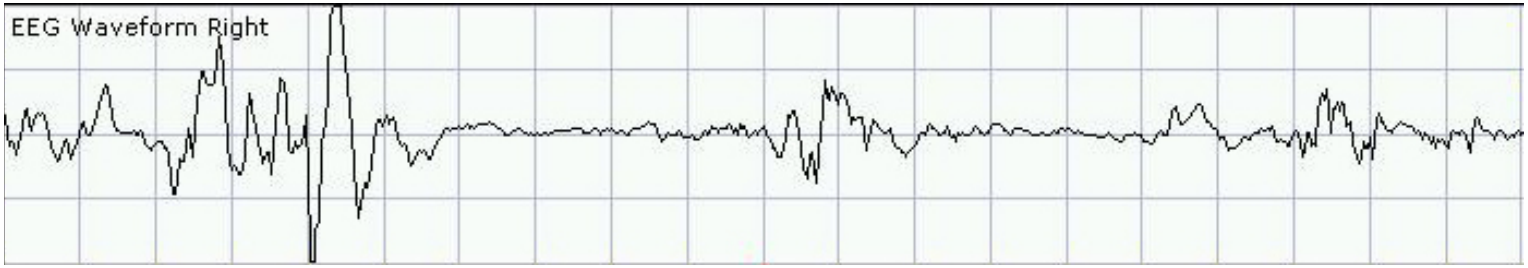
# Background Information - Channel




- Two electrodes are needed to create a single channel
- EEG waves reflect electrical voltage differences between these two electrodes sites
  - Measured in microvolts (µV)

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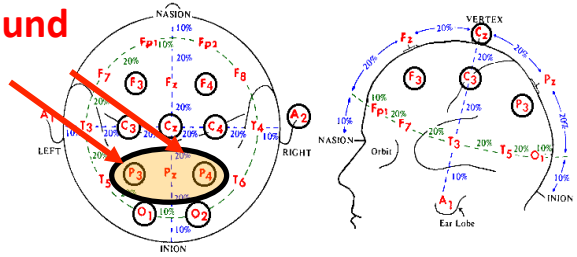
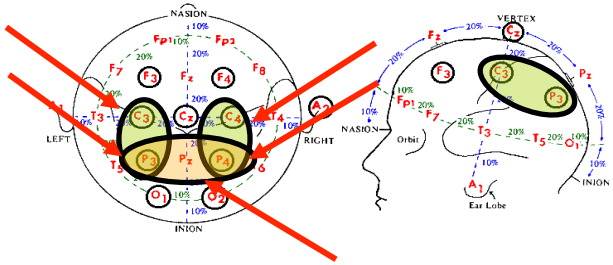
# aEEG Channels & the 10-20 System

- The Olympic Brainz Monitor may be used to monitor and record aEEG patterns through either:

  - **Cross-Cerebral (default mode)**
    - **3 electrodes - 2 active & 1 hydrogel ground**
    - 1 aEEG channel (P3/P4)
    - 1 EEG channel (P3/P4)




  - **Bilateral**
    - **5 electrodes – 4 active & 1 hydrogel ground**
    - 3 aEEG channels (C3/P3, C4/P4, P3/P4)
    - 3 EEG channels (C3/P3, C4/P4, P3/P4)



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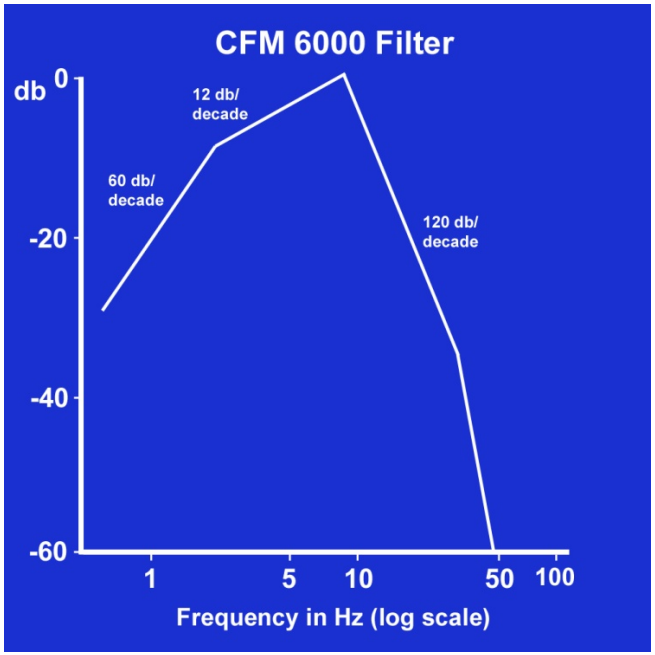
# Filtering

- The EEG signal is filtered 2–15 Hz
- Specially shaped filter
- Reduces muscle and other artifacts



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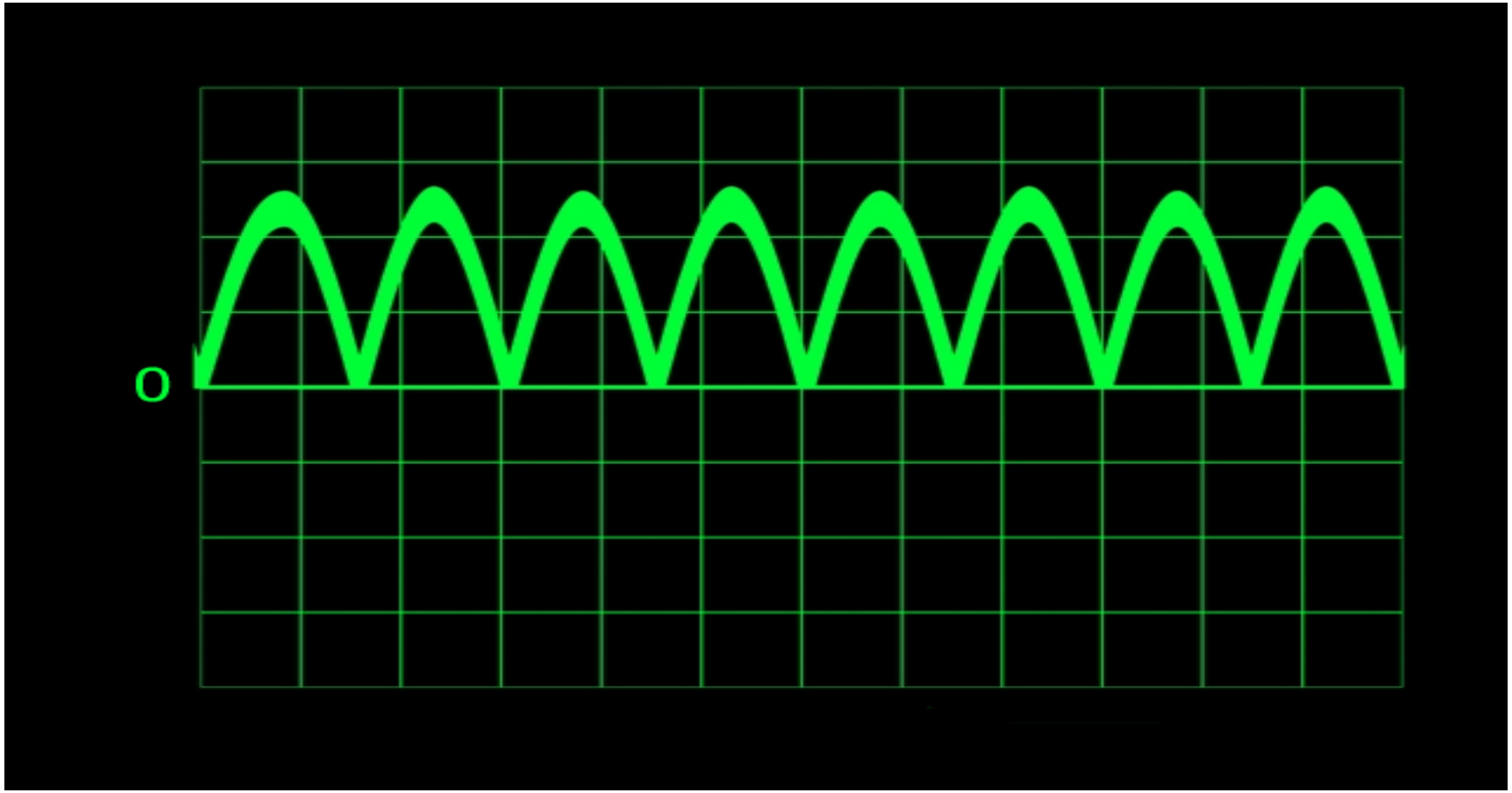
# Rectification



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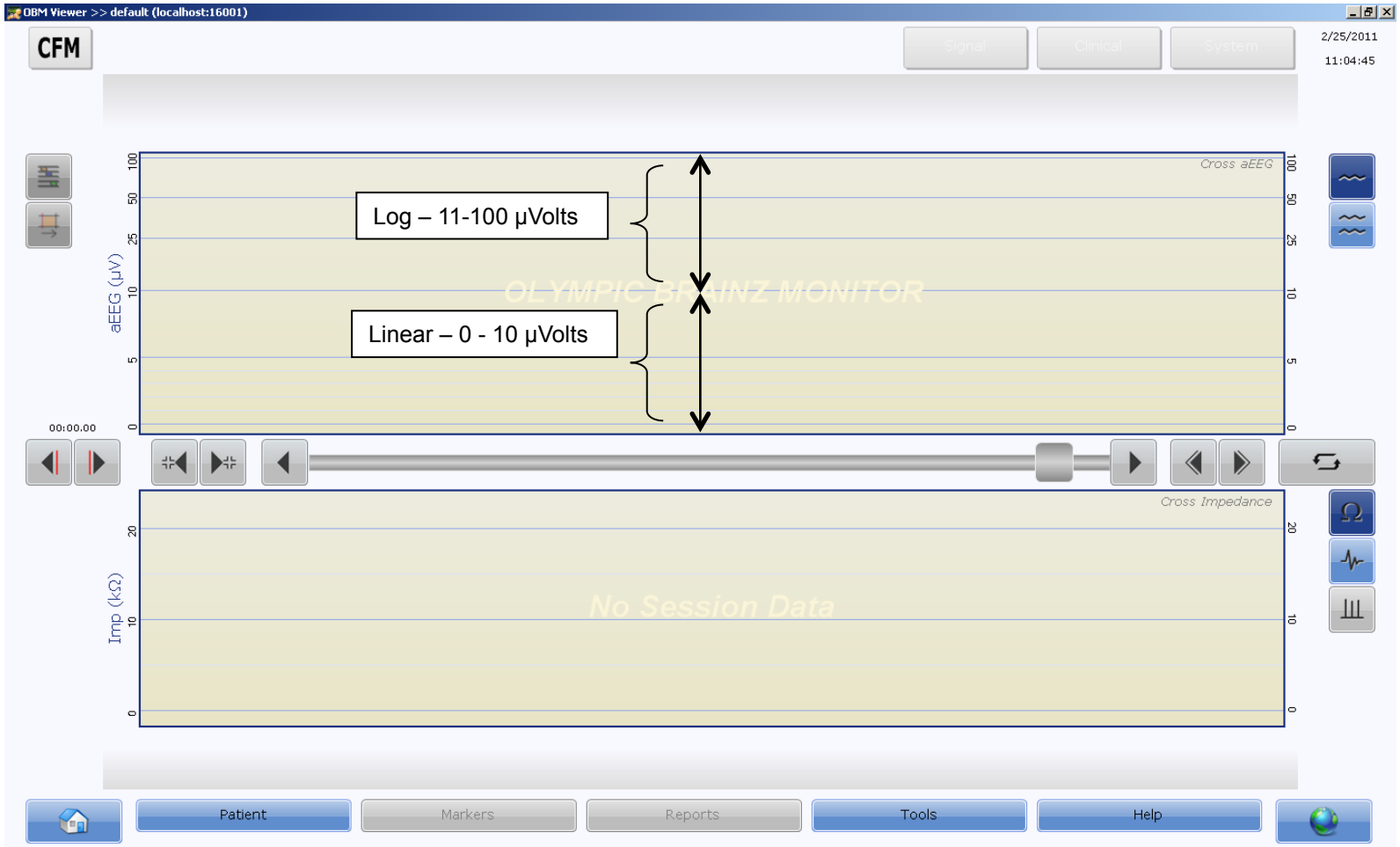
# Compression



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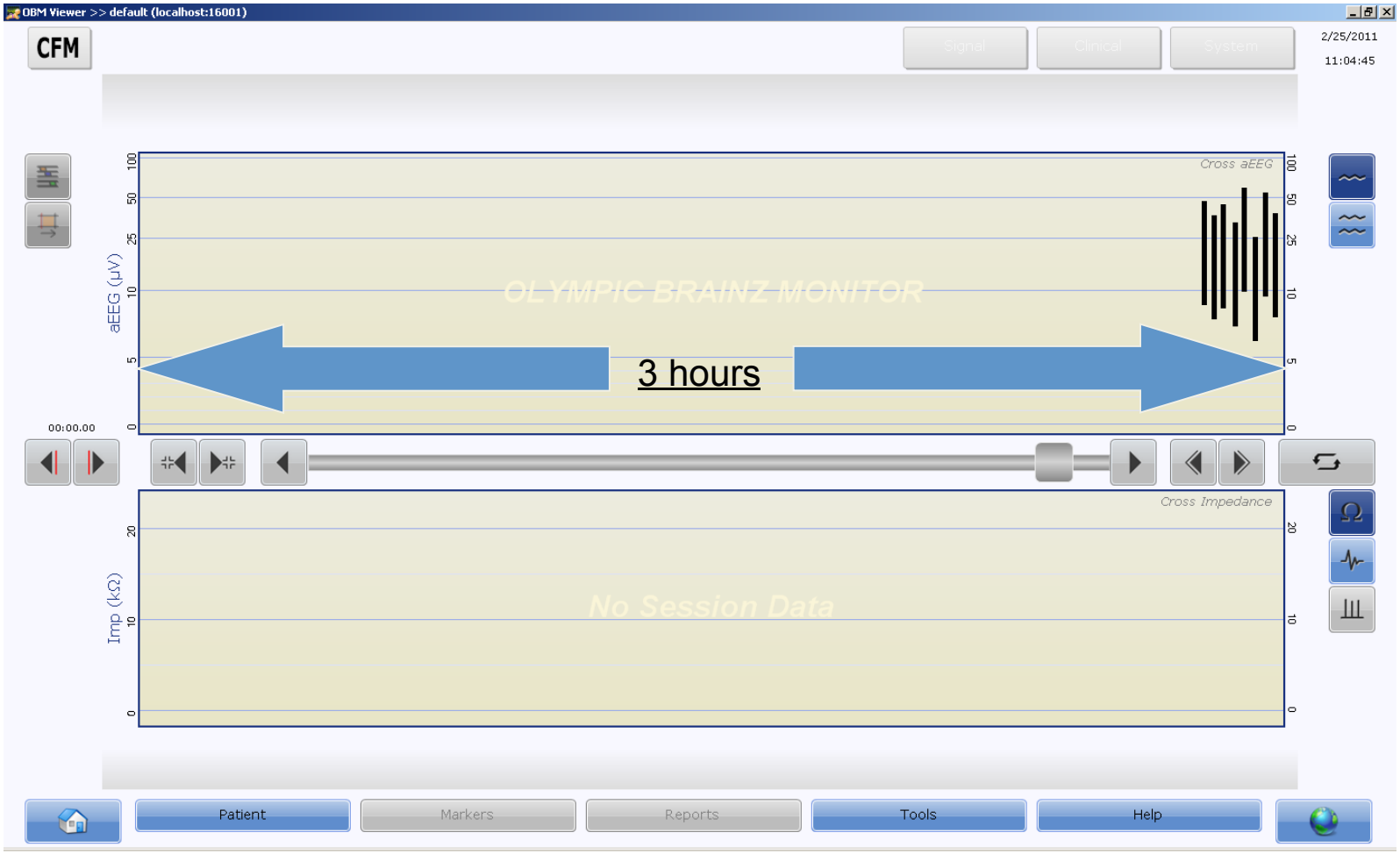
# Very Slow, Trend Display



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# Background Information - Margins

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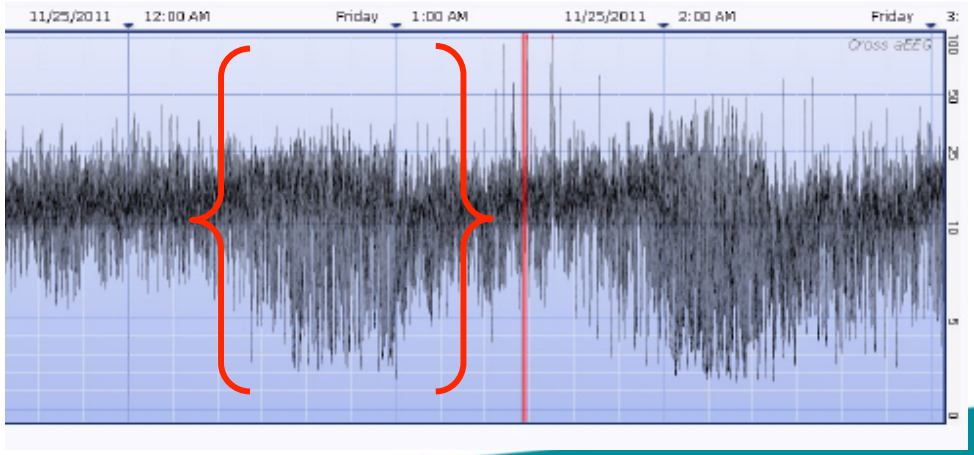
# Background Information – Sleep Wake Cycling (SWC)

- **SWC characterized by:**
  - Smooth sinusoidal variations, mostly in the lower margin
  - Broader bandwidth represents discontinuous background activity during quiet sleep
  - More narrow bandwidth corresponds to more continuous activity during wakefulness and active sleep
  - Quiet Sleep Cycle duration ≥ 20 minutes
    - Total SWC ~60-90 minutes



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# aEEG Classification Framework

Feb 2006 – NeoReviews – Hellstrom Westas

| *Pattern Definition (Hellstrom-Westas & Toet)* | *Lower Margin (in µV)* | *Upper Margin (in µV)* |
|---|---|---|
| Continuous Normal Voltage | > 5 | >10 |
| Discontinuous Normal Voltage | <5 | >10 |
| Burst Suppression | <5 | >10 due to high voltage bursts |
| Continuous Low Voltage | <5 | <10 |
| Isoelectric/Flat | < 5 | <5 |

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# aEEG and TERM Babies

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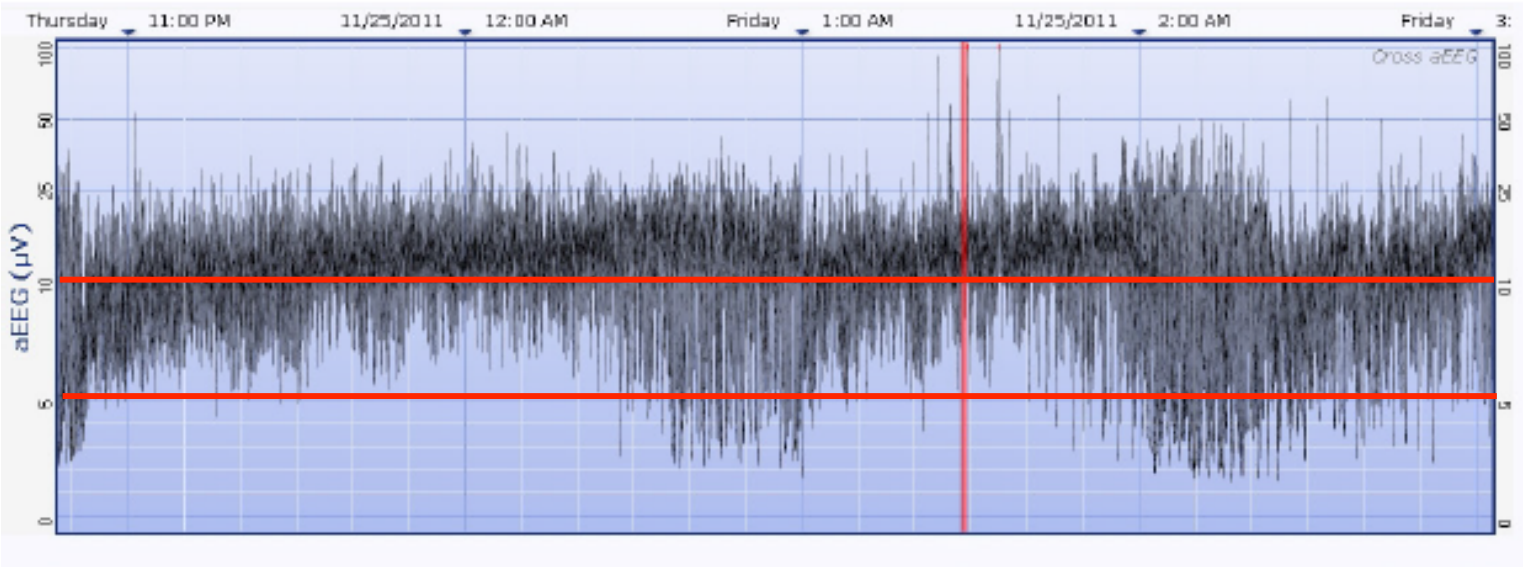
# Continuous Normal Voltage

- Sleep/Wake Cycling
- Upper Margin > 10 µVolts
- Lower Margin > 5 µVolts
- Limited Bandwidth Variability (between upper and lower margin)
  - ~5-10 µVolts



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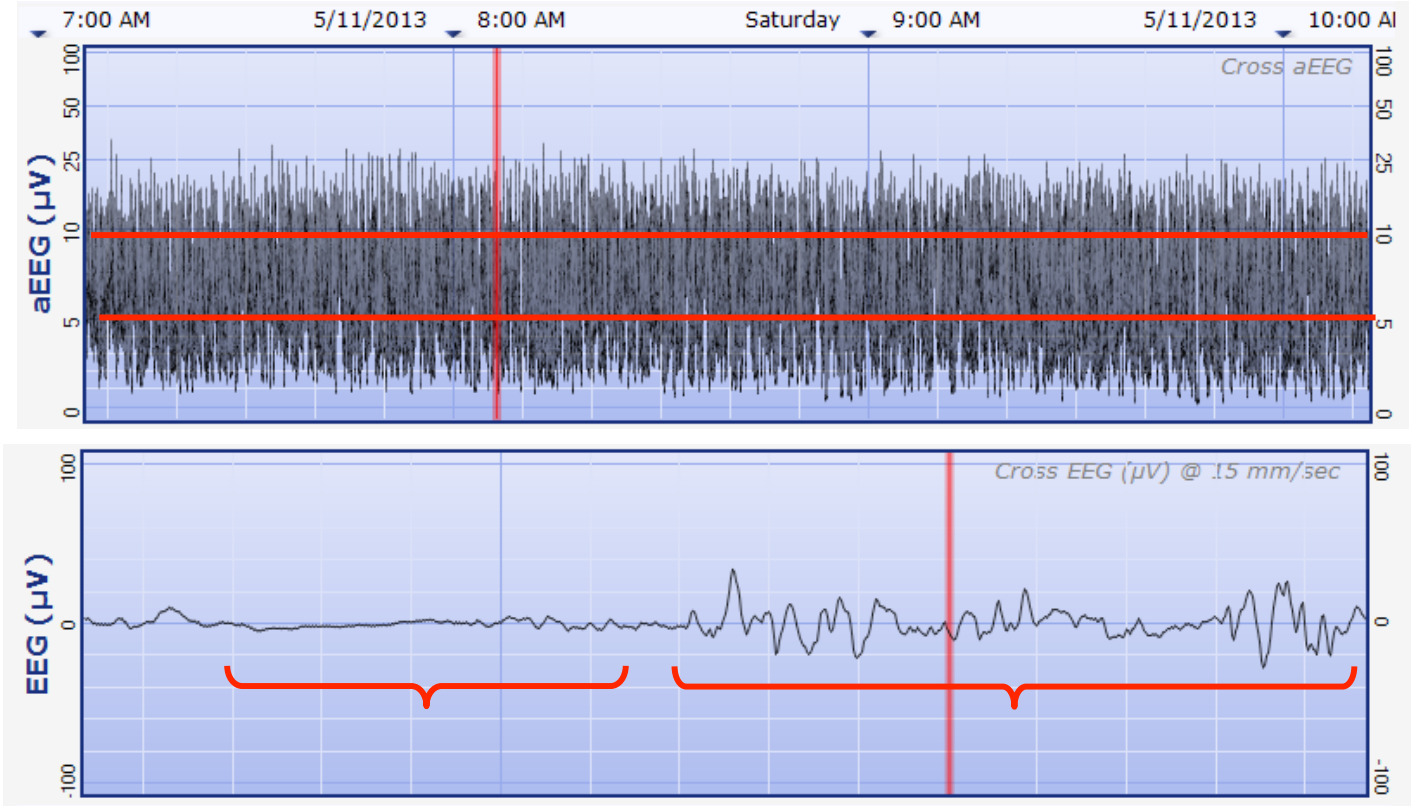
# Discontinuous Normal Voltage

- No Sleep/Wake
- Upper Margin > 10 µVolts
- Lower Margin < 5 µVolts
- Increased Bandwidth Variability
  - ~30 – 40 µVolts



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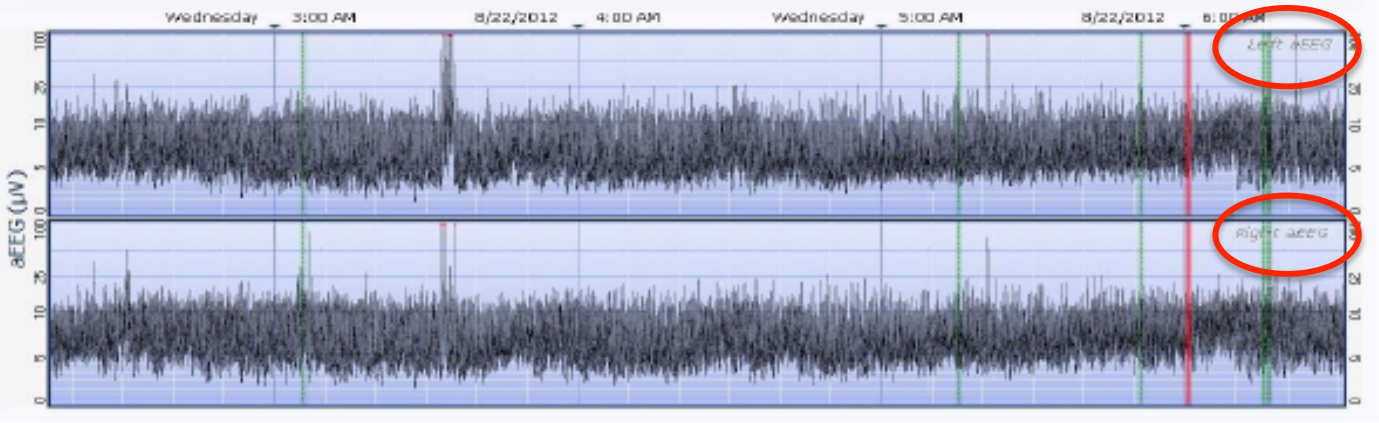
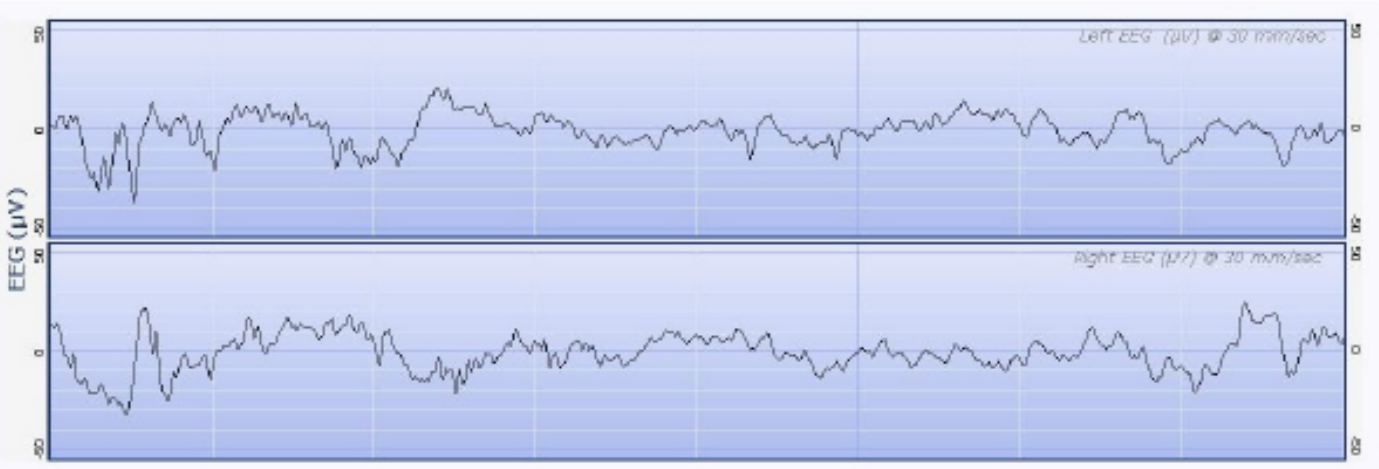
# Discontinuous Normal Voltage



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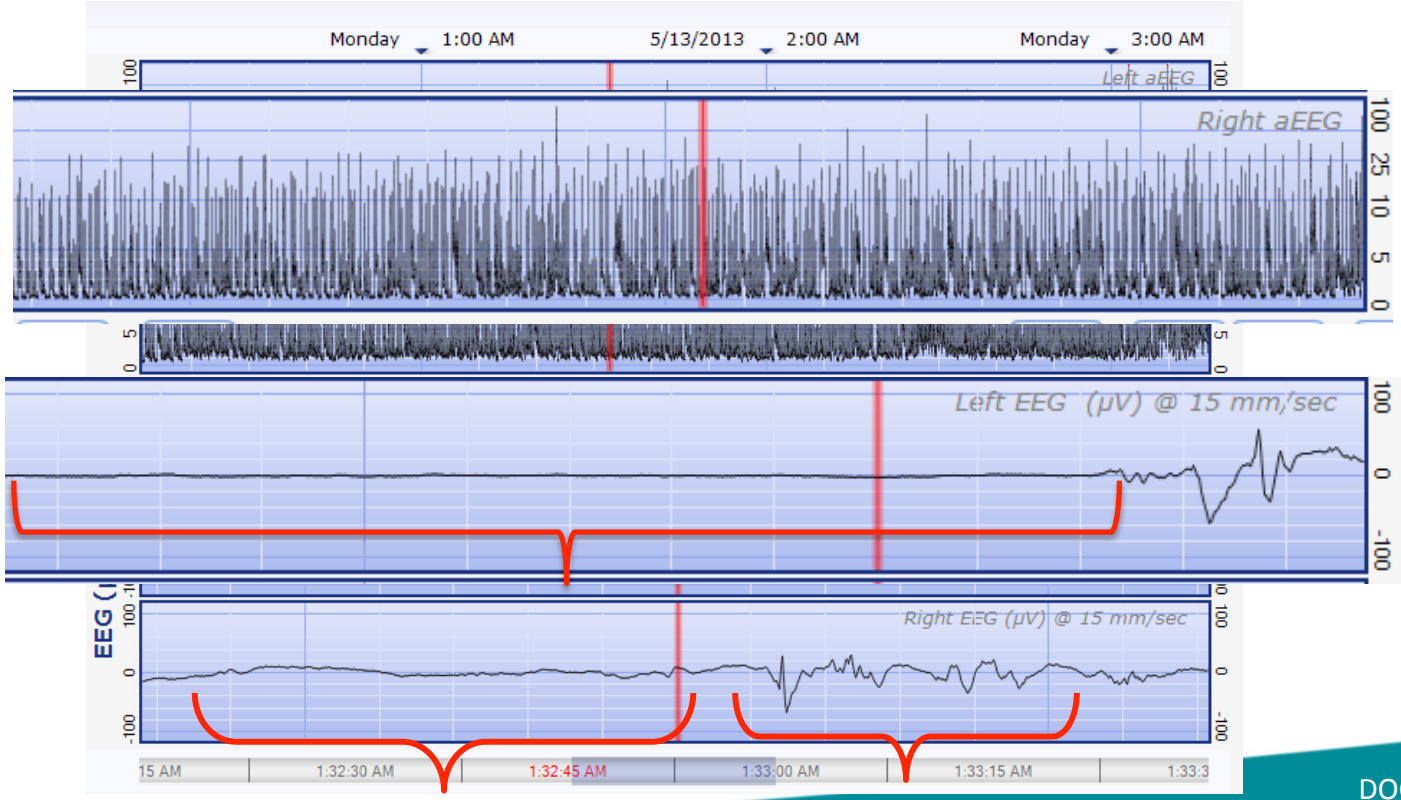
# Burst Suppression

- No Sleep Wake Cycling
- Upper margin >10µV (due to high voltage bursts)
- Lower margin <5µV
- Limited variability of lower margin



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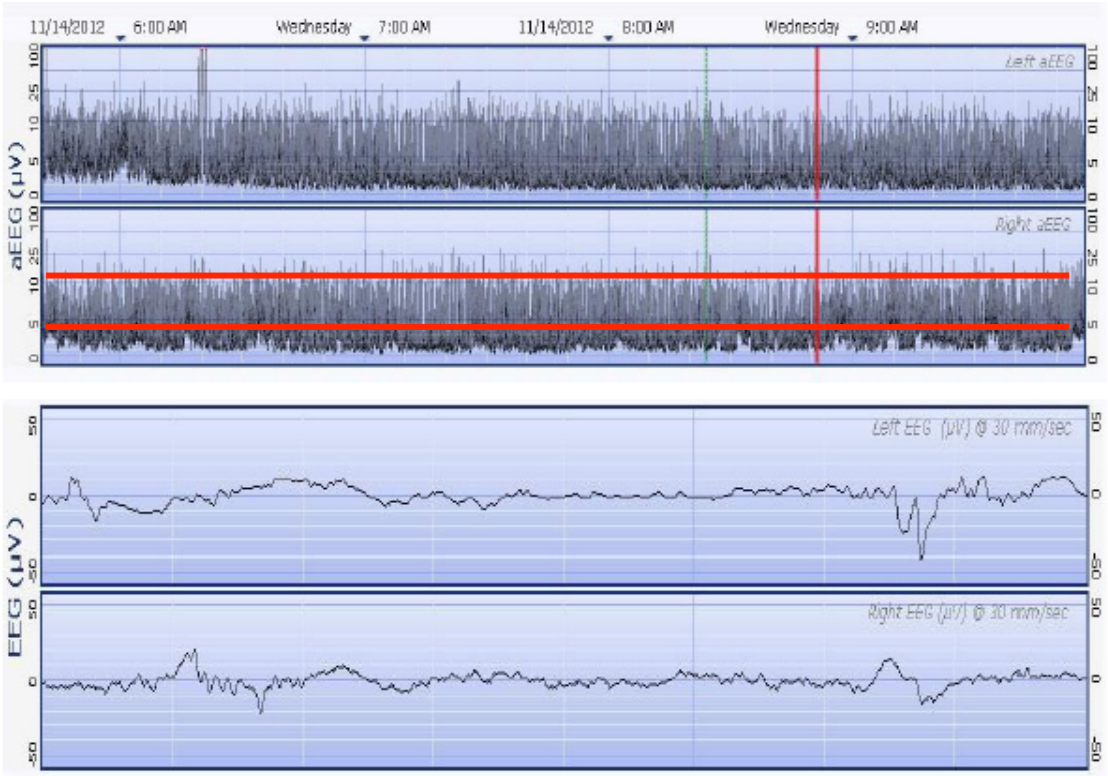
# Continuous Low Voltage

- No Sleep/Wake Cycling
- Upper margin <10uV
- Lower margin <5uV



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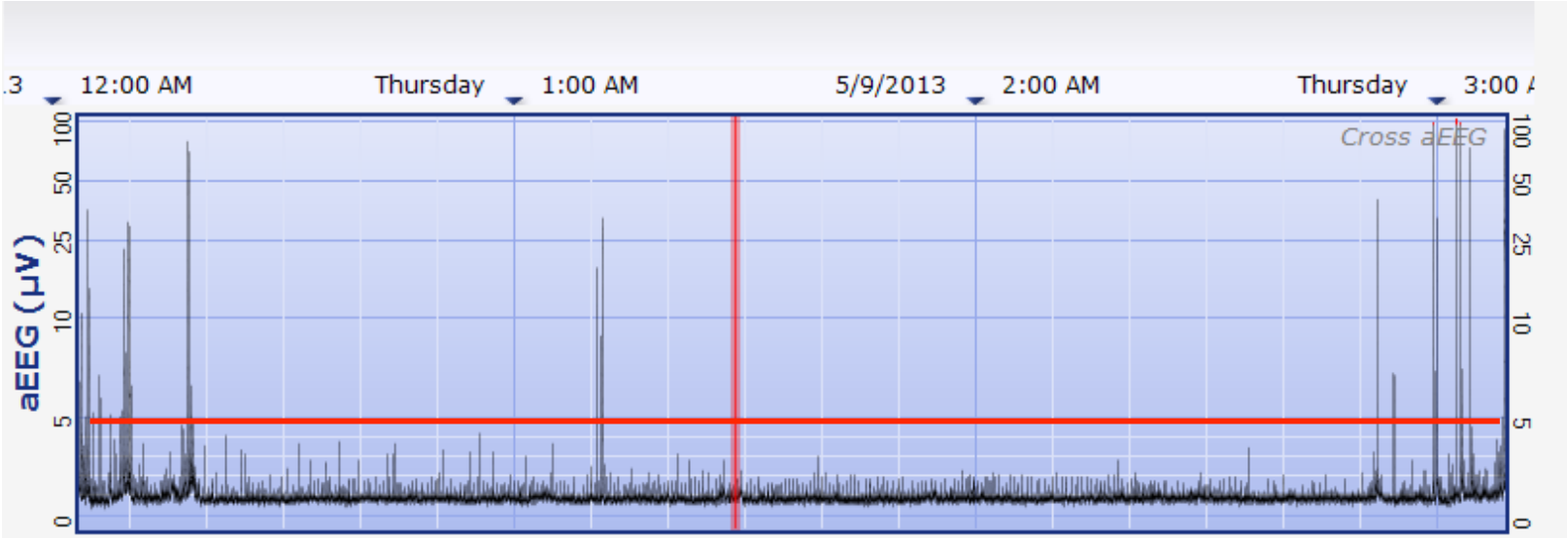
# Isoelectric or Flat

- No Sleep/Wake
- Upper Margin < 5 µVolts
- Greatly reduced bandwidth variability
  - ~1 µVolt



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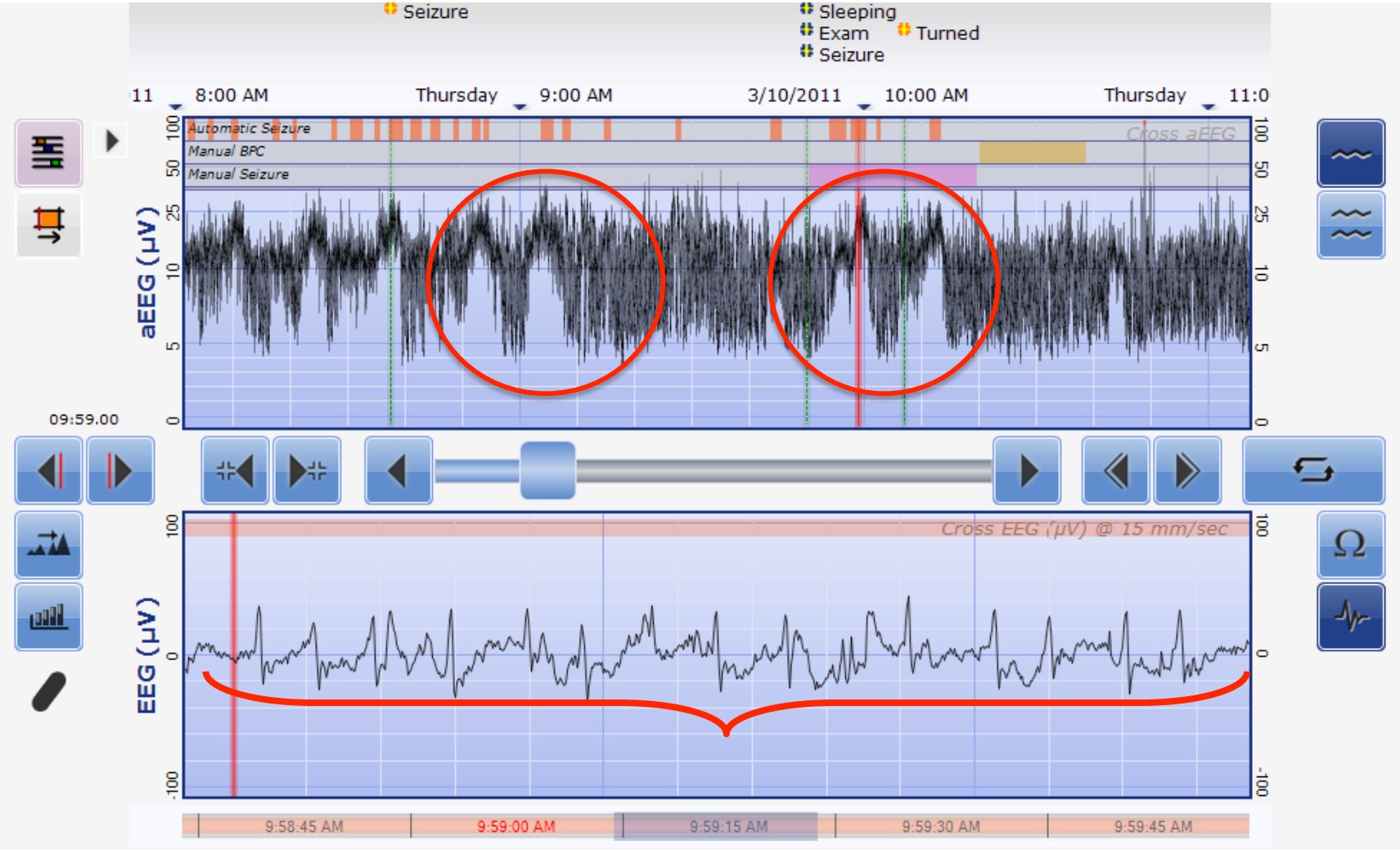
# Seizure EEG



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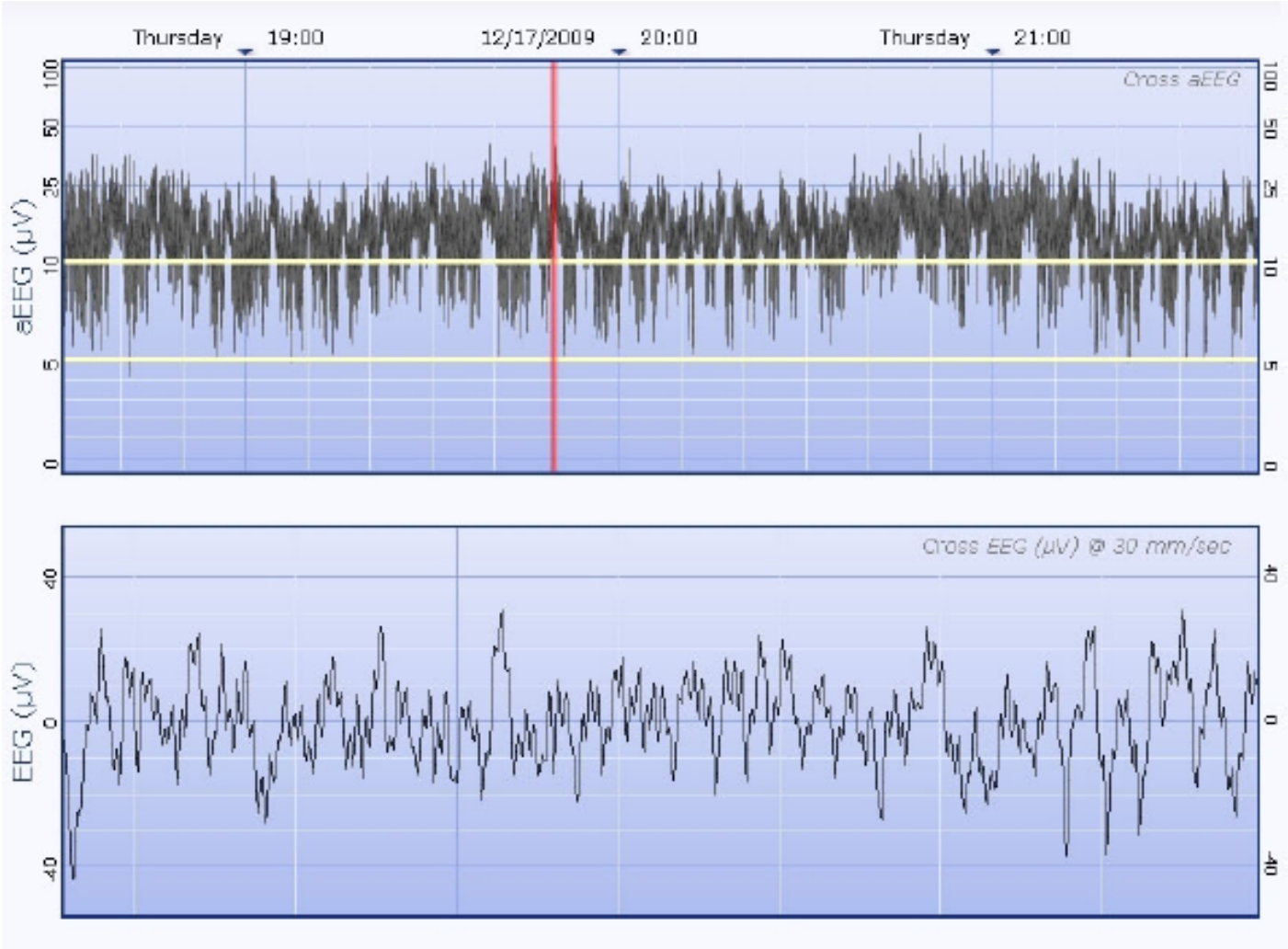
# Status Epilepticus



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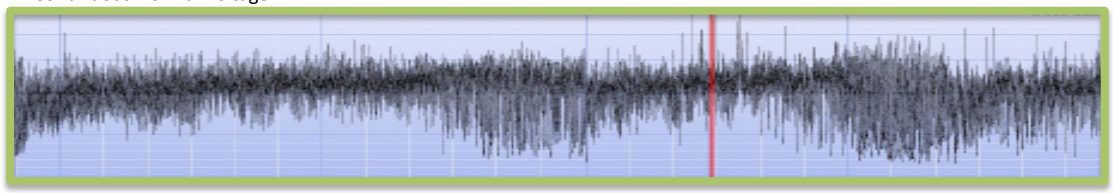
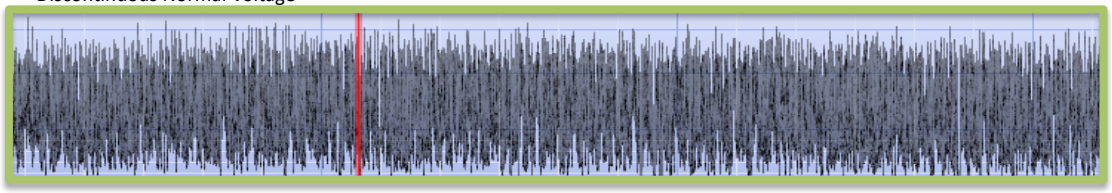
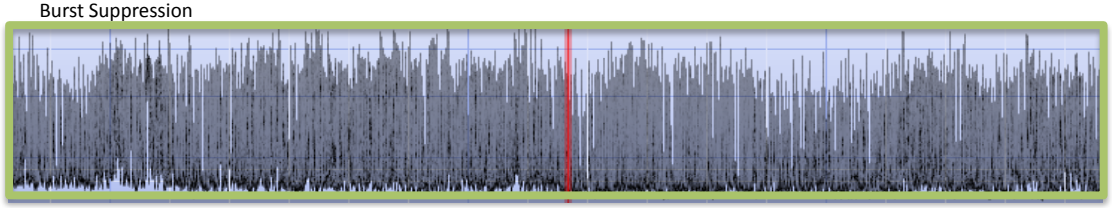
Continuous Normal Voltage



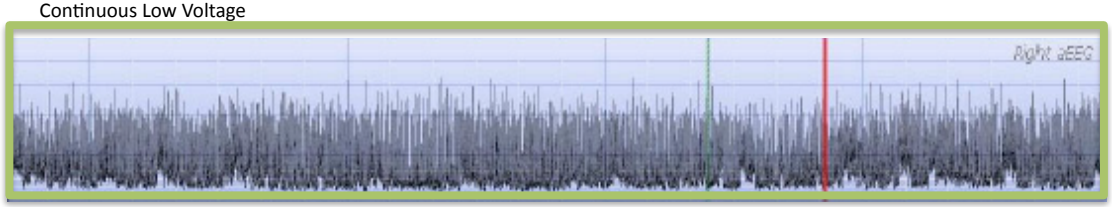
Discontinuous Normal Voltage



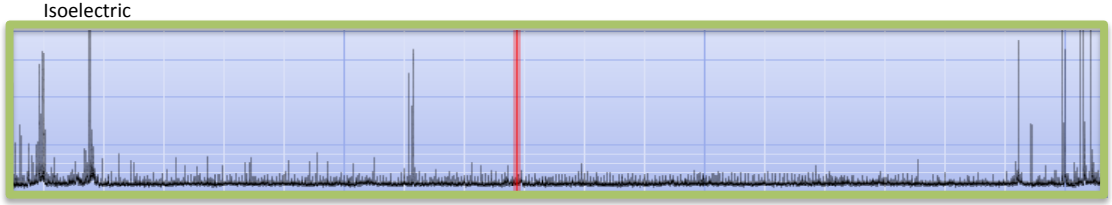
Burst Suppression



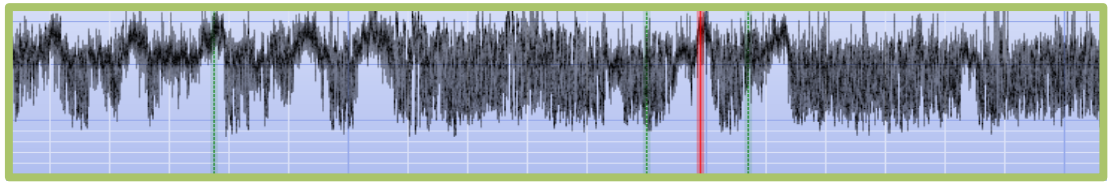
Continuous Low Voltage




Isoelectric



Seizures



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# Impedance and Artifact

- **Impedance**
  - A measure of the quality of electrode contact
  - Anything that gets between the sensor (hydrogel or low impedance needles) and "impedes" or interferes with the devices ability to read the brain signal (hair, dry skin, vernix)

- **Artifact**
  - Any electrical activity other than the brain's electrical activity (monitors, IV pumps, ventilators, etc.)
  - Live EEG signal is used as a point of reference to confirm suspected brain activity OR to distinguish artifact from the real signal

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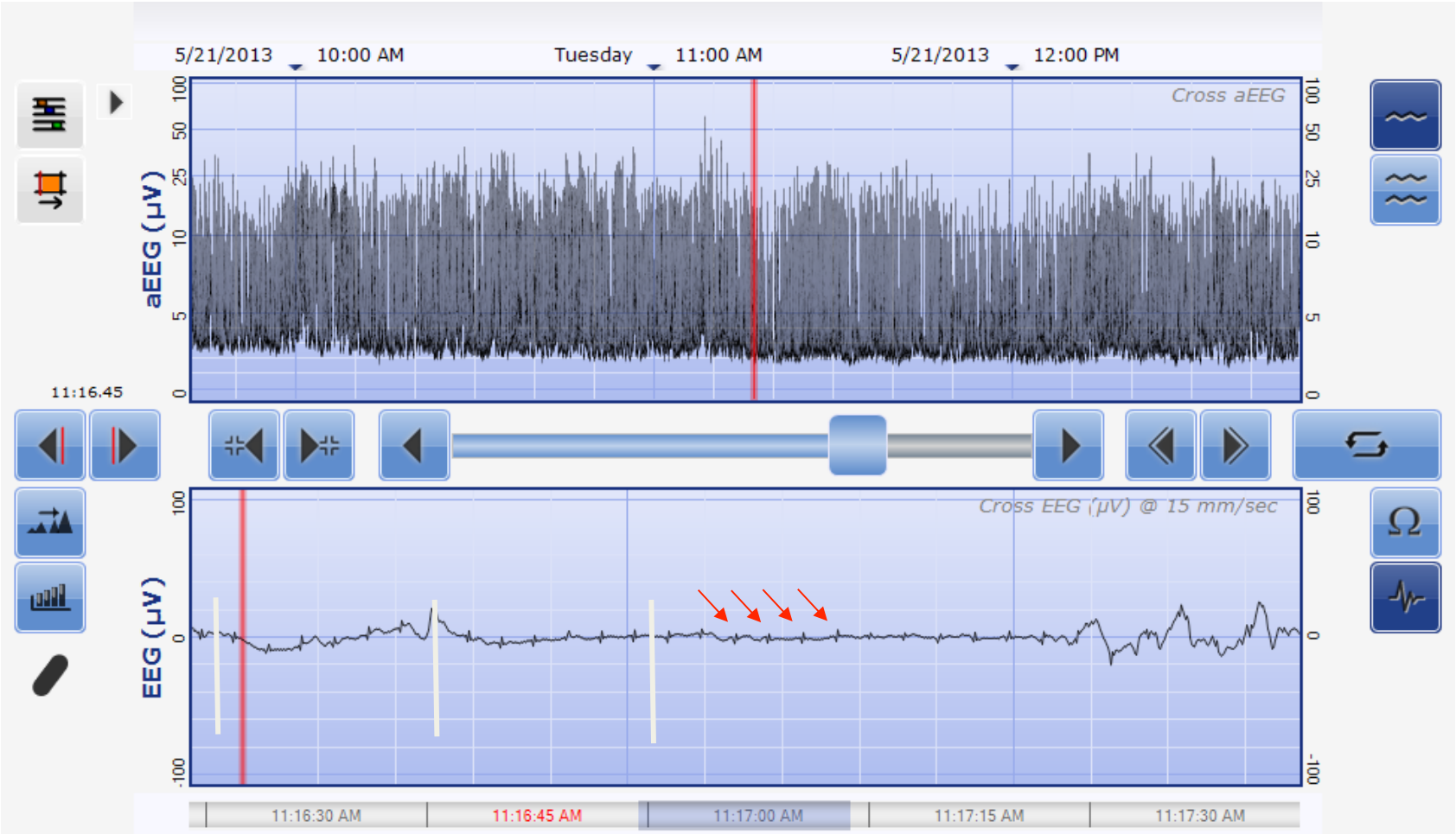
# ECG Artifact



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# aEEG and Premature Babies

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# Pre-Term Infants

| Gestational or Postconceptual Age (wk) | Dominating Background Pattern | SWC | Minimum Amplitude (mcV) | Maximum Amplitude (mcV) | Burst/h |
|---|---|---|---|---|---|
| 24 through 25 | DC | (+) | 2 to 5 | 25 to 50 (to 100) | >100 |
| 26 through 27 | DC | (+) | 2 to 5 | 25 to 50 (to 100) | >100 |
| 28 through 29 | DC/(C) | (+)/+ | 2 to 5 | 25 to 30 | >100 |
| 30 through 31 | C/(DC) | + | 2 to 6 | 20 to 30 | > 100 |
| 32 through 33 | C/DC in QS | + | 2 to 6 | 20 to 30 | > 100 |
| 34 through 35 | C/DC in QS | + | 3 to 7 | 15 to 25 | >100 |
| 36 through 37 | C/DC in QS | + | 4 to 8 | 17 to 35 | > 100 |
| 38+ | C/DC in QS | + | 7 to 8 | 15 to 25 | > 100 |

SWC: (+) = imminent/immature; SWC: + = developed; SWC: QS = quiet/deep sleep;
DC = discontinuous background pattern; (C) = continuous

*NeoReviews*. Vol 7 No. 2 February 2006
Hellstrom-Westas, Rosen, deVries, Greisen

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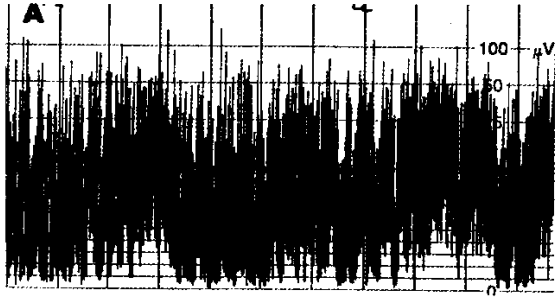
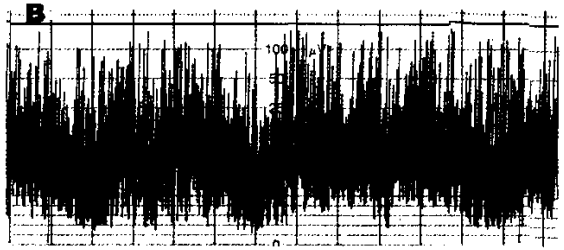
# Normal aEEG's at Various Gestational Ages

*Thornberg & Thiringer 1990, Kuhle et al 1999)*

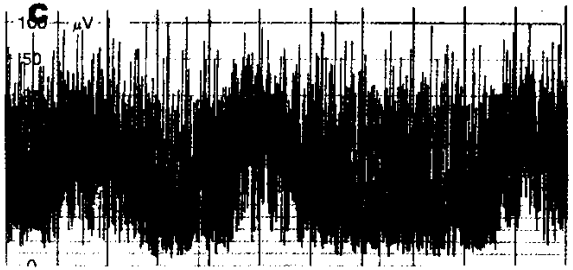
24 w

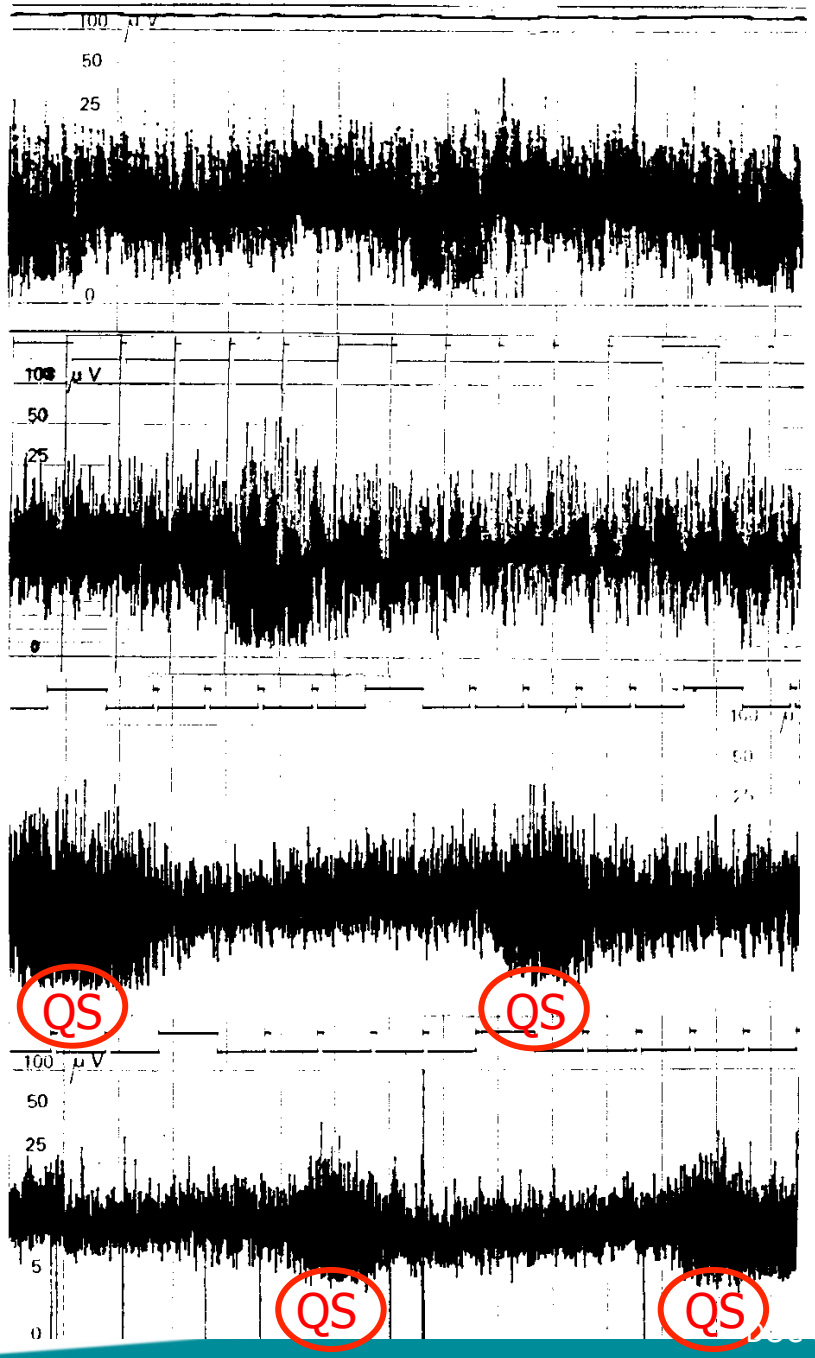



25 w




26 w



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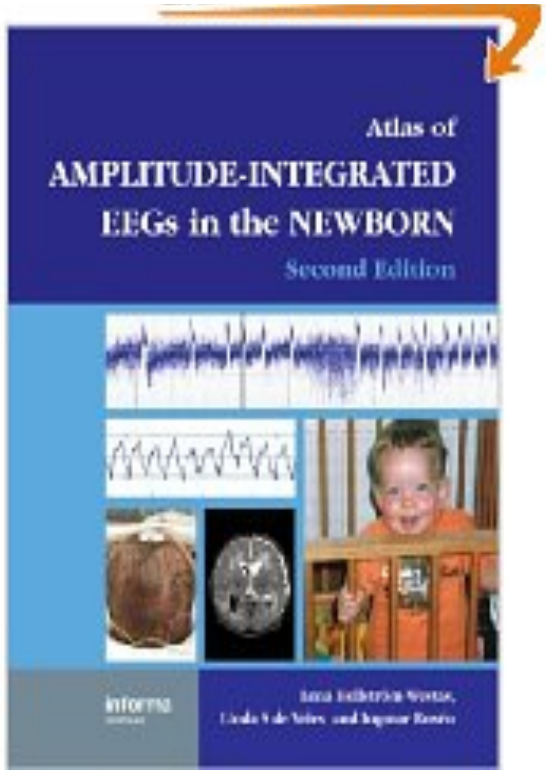
# aEEG Reference Literature

Reference:

- Atlas of Amplitude-Integrated EEGs in the Newborn: Second Edition (*Hellstrom-Westas, De Vries, Rosen; 2008)*



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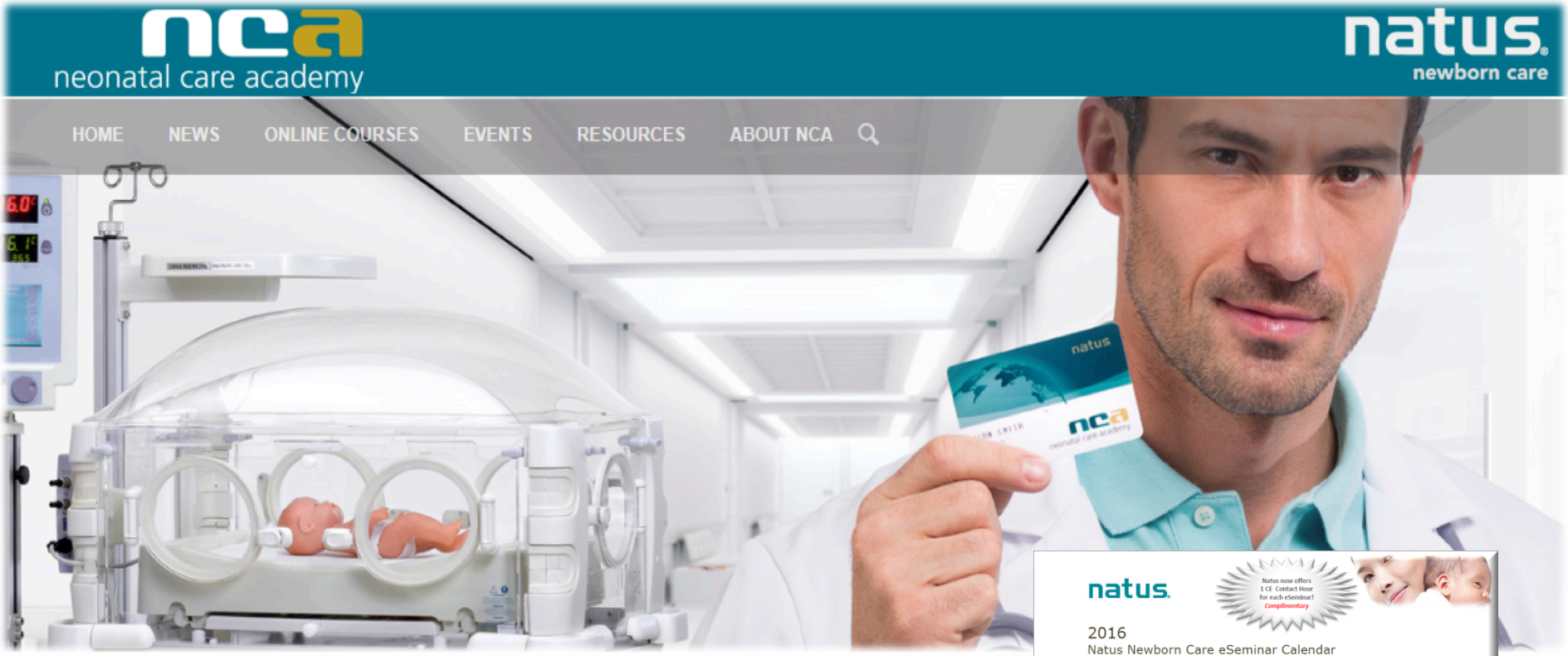


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2016
Natus Newborn Care eSeminar Calendar

FEBRUARY
Thermoregulation 101
February 2, 2016
*eSeminar*

MARCH
Basics of aEEG
March 15, 2016
*eSeminar*

APRIL
Assessing Jaundice in the Newborn Infant
April 26, 2016
eSeminar

MAY
Humidifying the Microenvironment
May 3, 2016
eSeminar

JUNE
Family Centered Care
*By Personal Invitation to Neonatal Care Academy Members*
June 21, 2016
eSeminar

JULY
Optimizing the Thermal Environment – Creating a Comfort Zone
July 26, 2016
eSeminar

SEPTEMBER
Basics of aEEG
September 20, 2016
eSeminar

OCTOBER
Creating a Healing Environment
October 4, 2016
eSeminar

NOVEMBER
Science of Hyperbilirubinemia and Clinical Evidence Review
November 1, 2016
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