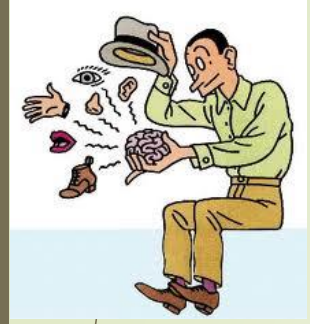


Department of Neuroscience

Erasmus Medical Center

Erasmus MC
Universitair Medisch Centrum Rotterdam

# *Trading detection accuracy for battery autonomy in a wearable seizure-detection device*

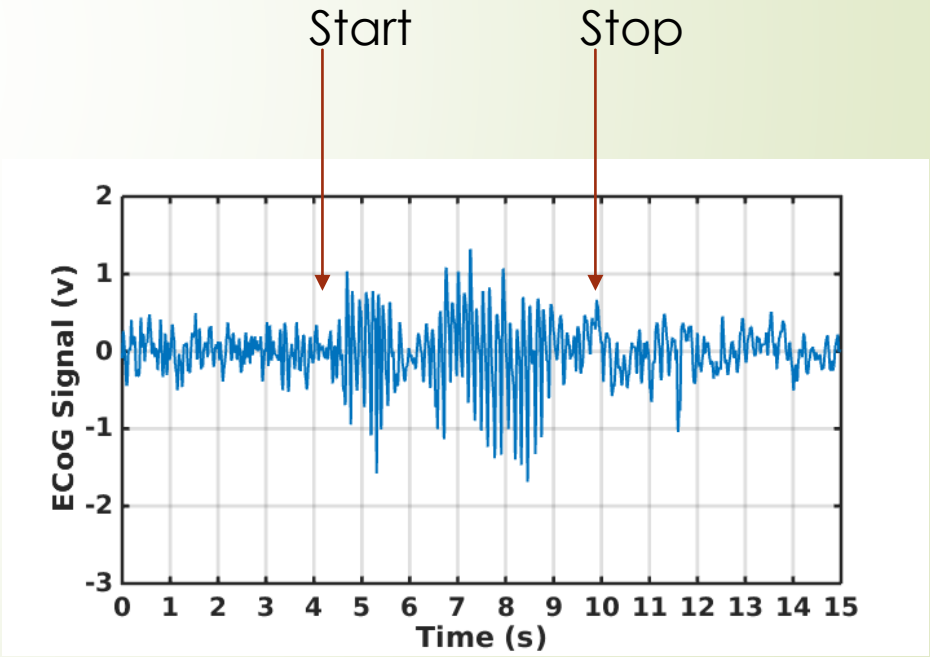
Christos Strydis, Robert M. Seepers, Athanasios Karapatis

DeSyRe
on-Demand System Reliability

brain project

# Problem description

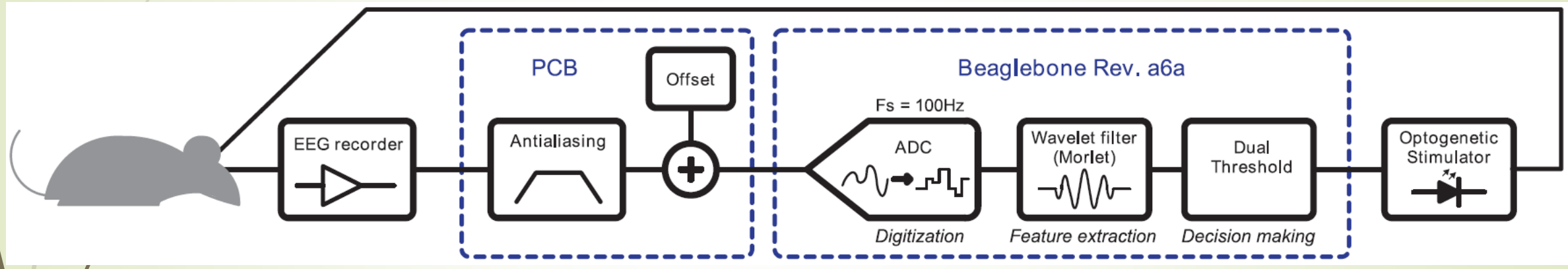
- What are **absence (*"petit-mal"*) seizures**
  - Macro: Brief loss and return of consciousness, motionless stare
  - Micro: Ictal-activity in EEG or ECoG
- How do they look like?



# Challenges of a seizure preventor

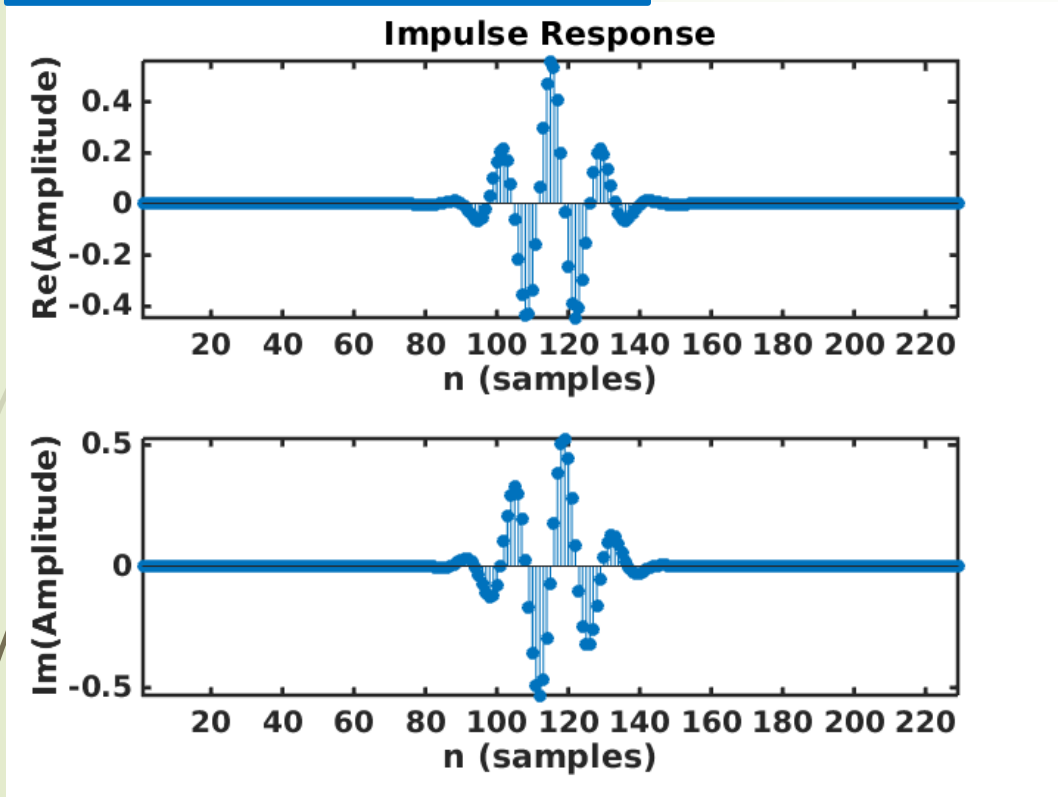
- Current challenges?
  - Fast and correct detection < 1 sec
  - No "golden standard" for ictal activity
- A novel closed-loop system with an efficient filter achieving:
  - Seizure prevention within 1 sec of seizure onset
  - Energy-efficiency for wearability (later, implantable device)
- Figures of merit to be optimized:
  - **Filter sensitivity** ← Percentage of successfully detected **seizures**
  - **Filter specificity** ← Percentage of correctly classified **inter-ictal intervals**
  - **Filter detection delay**
  - **Energy cost**

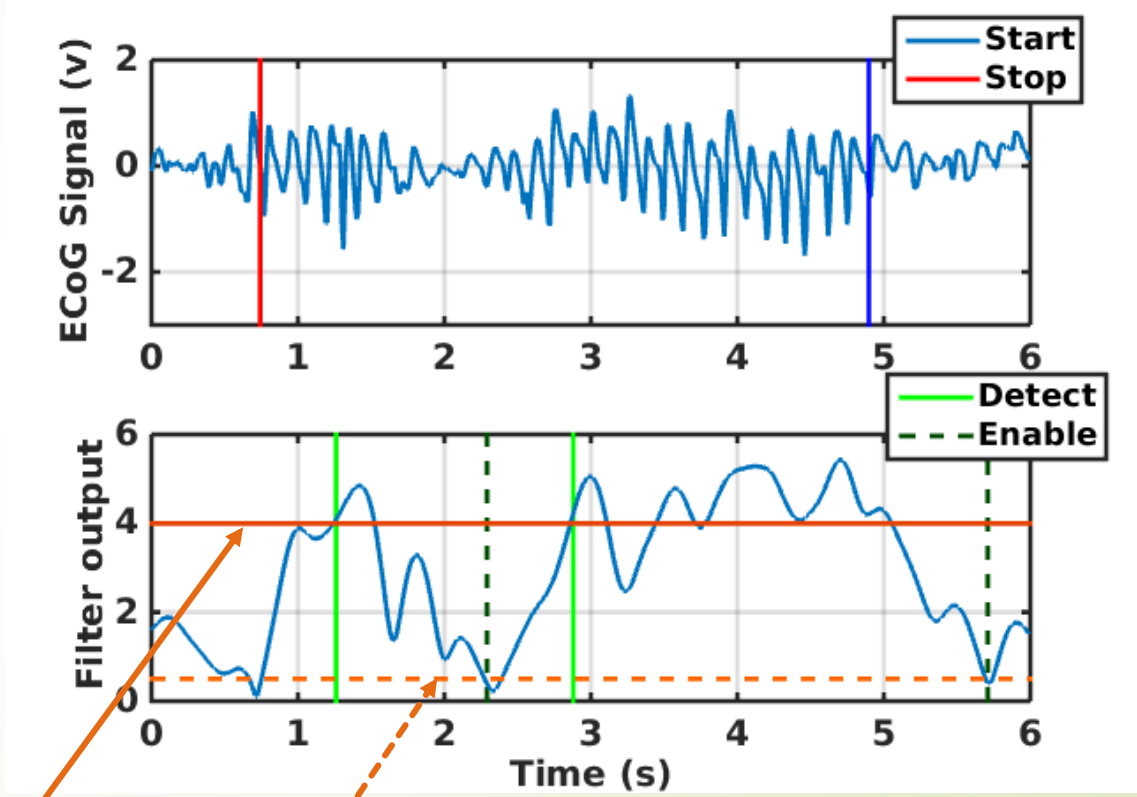
# Seizure-prevention system



# Seizure-prevention concept

Morlet wavelet as **FIR filter**

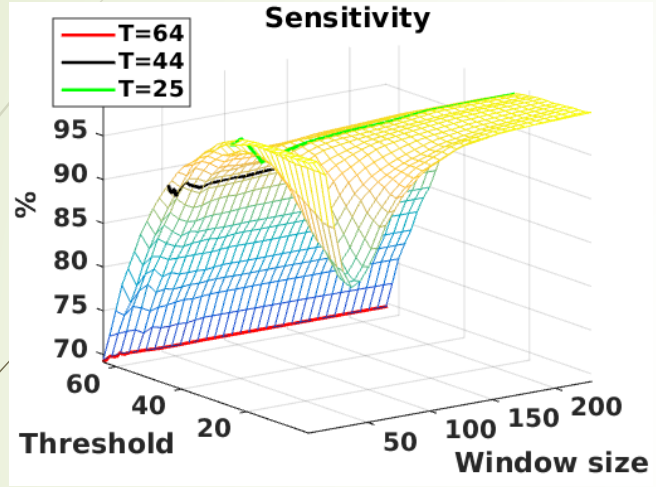


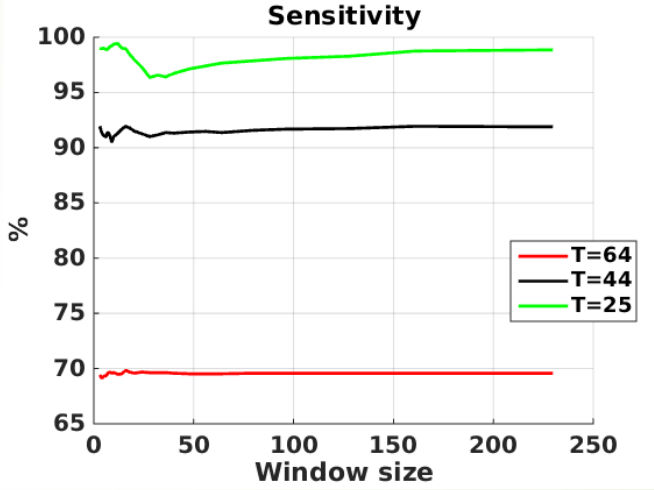



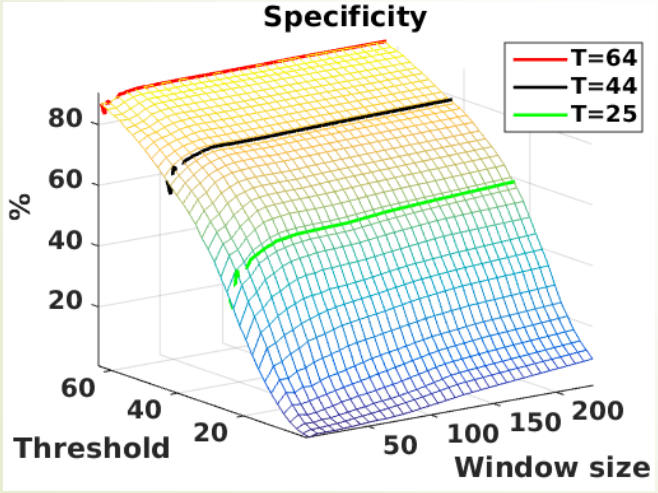

Upper Threshold

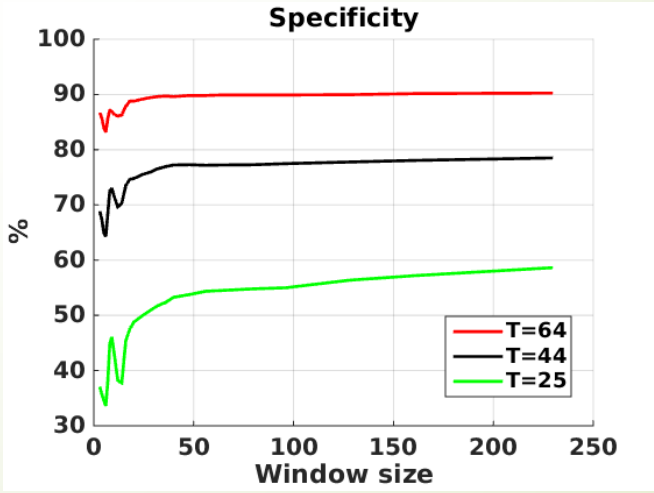
Lower Threshold

# Window size vs. Sensitivity & Specificity

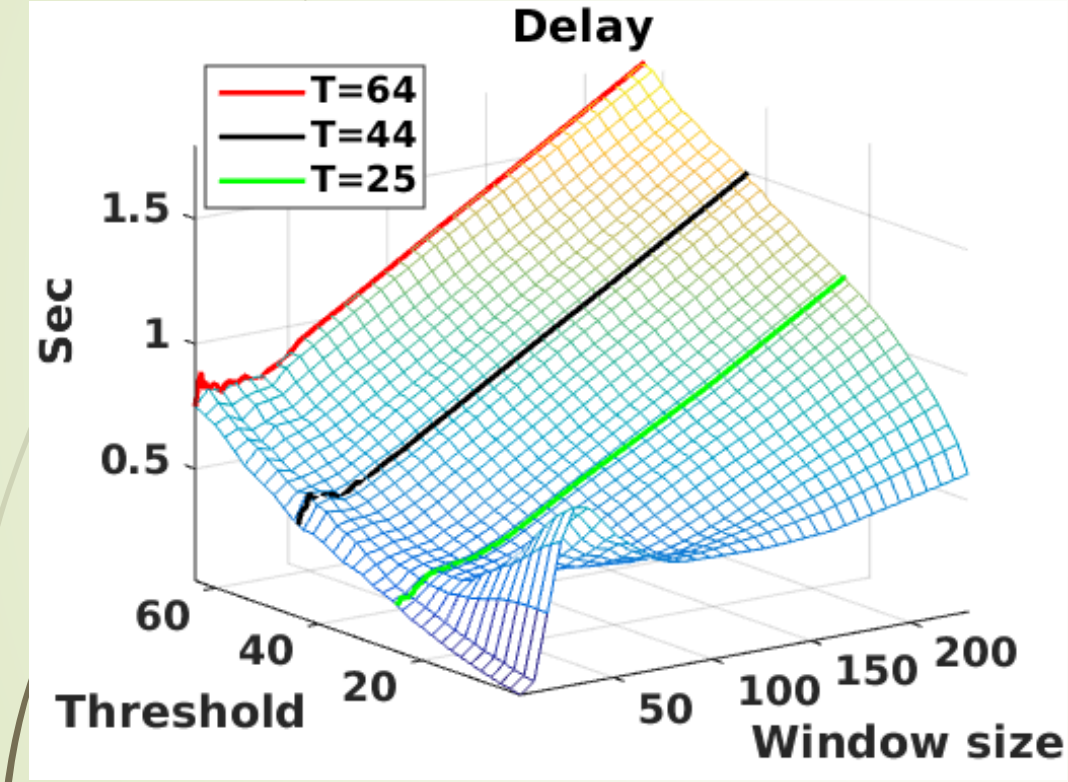


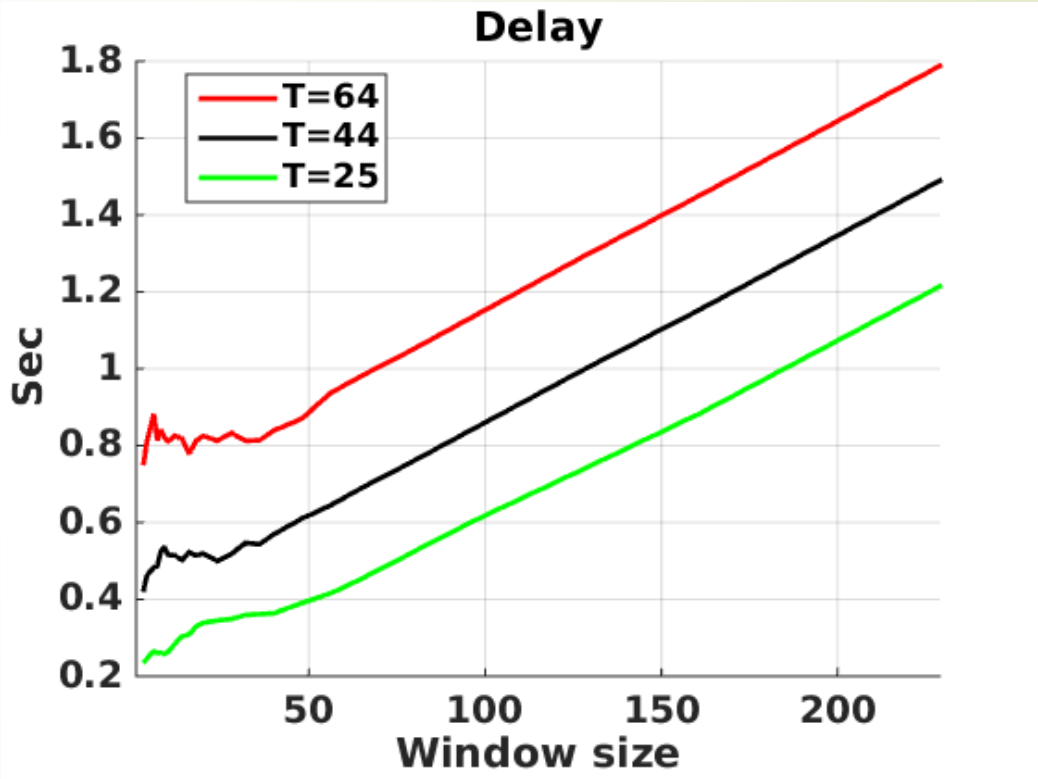



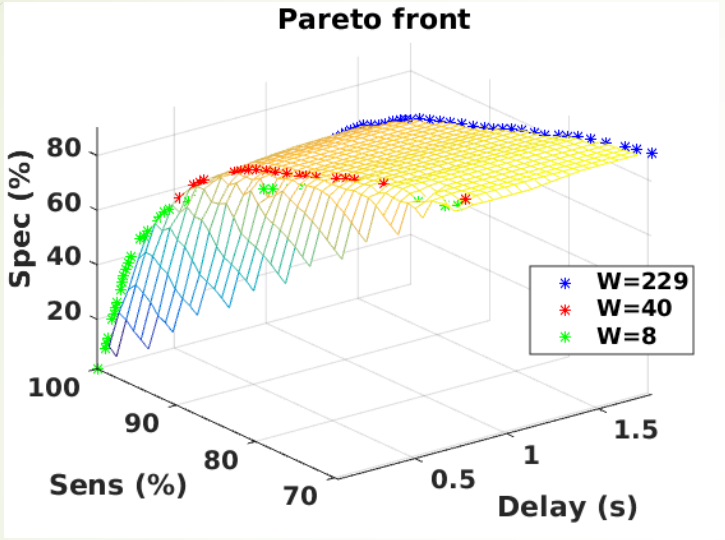



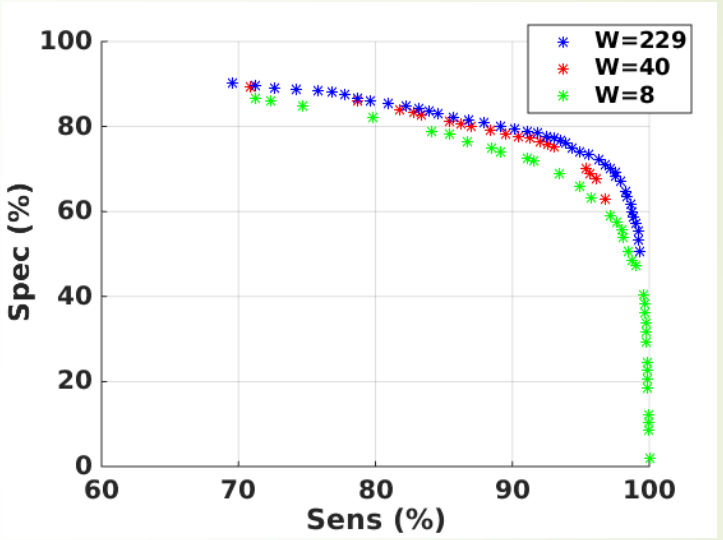
# Window size vs. Detection delay



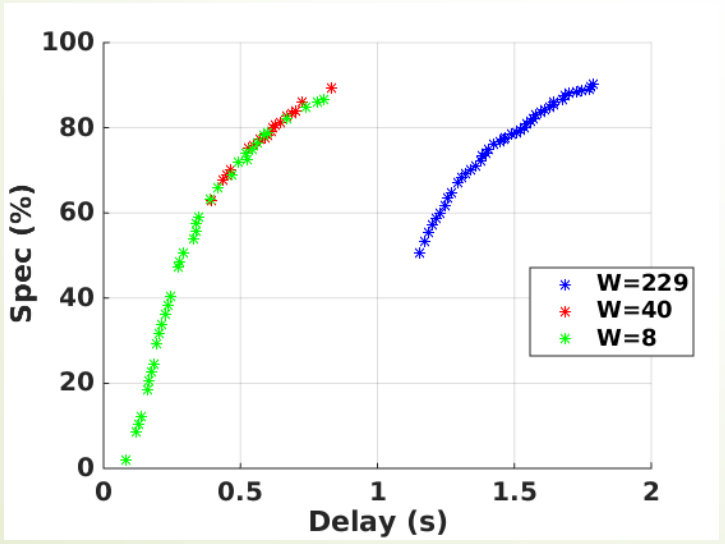



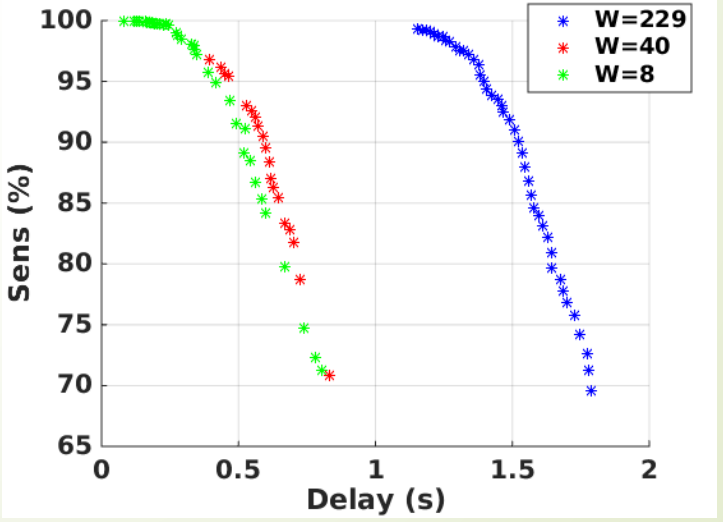
# System design space



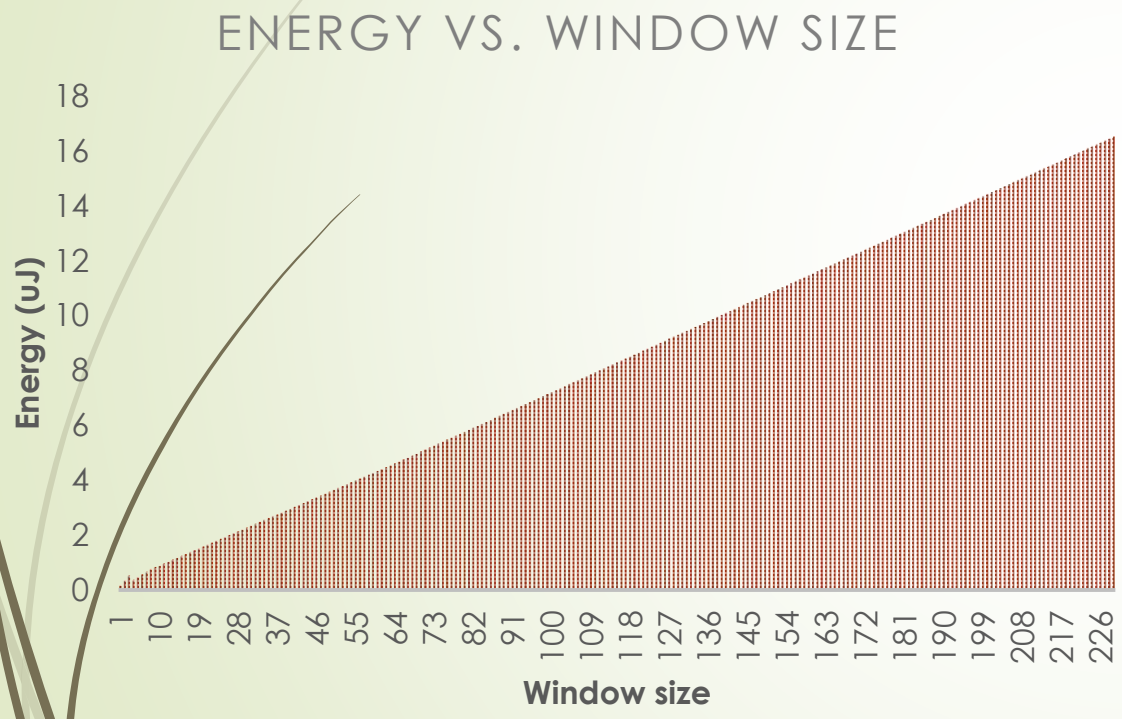

$$ADR = \frac{sens + spec}{2}$$

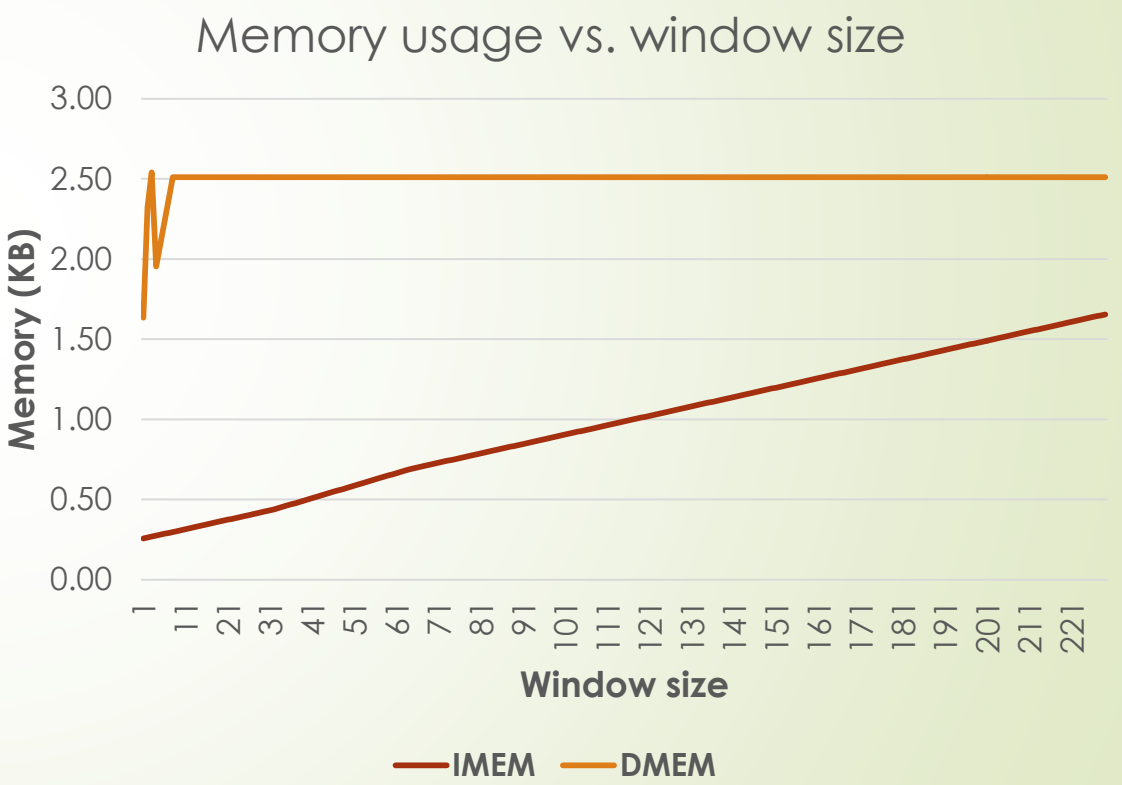



Energy???

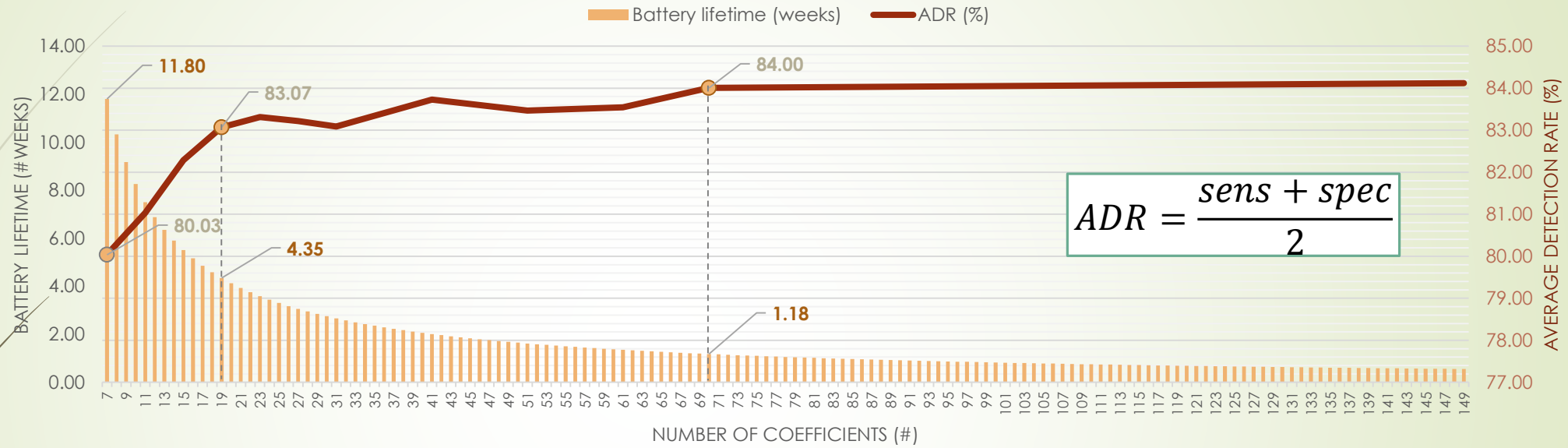
# Architectural aspects

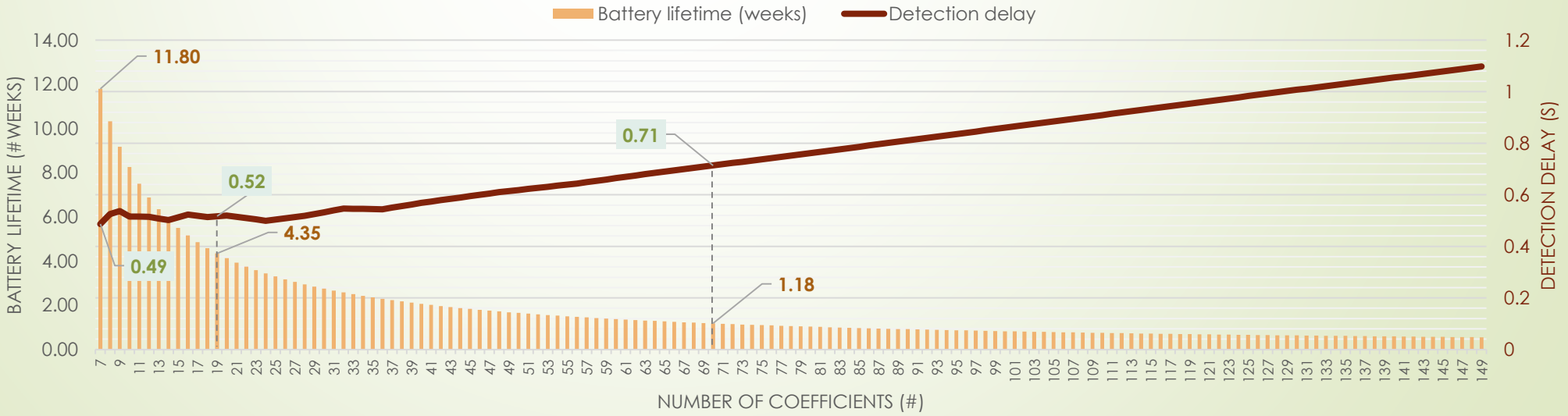



**FIR-filter execution latency…**

# Energy-efficient system design

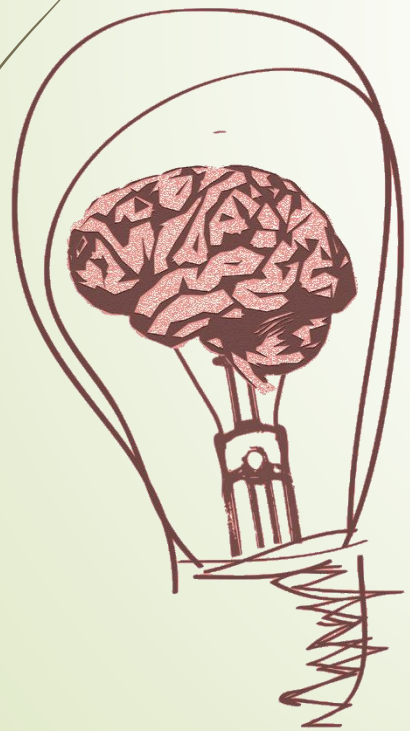


# Conclusions & Future work

- Exploiting:
  1. "Fuzziness" of biological phenomena
  2. Non-linearity of system characteristics
- Results in major battery savings with minor / non-observable performance impact!
  - e.g. **3.7x** increase in device autonomy at no observable penalty for test animals
- Can be extended to other sorts of FIR filters, other aspects of ultra-constrained biomedical devices
- Future work
  - Window offset
  - Adaptive-threshold mechanism
  - Different wavelet filter

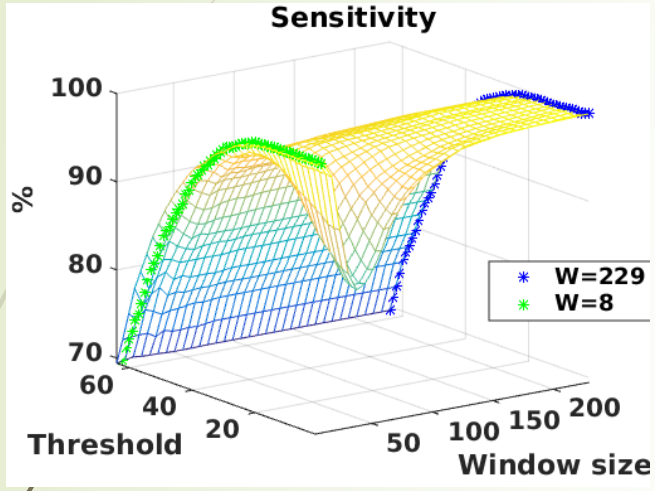
# Thank you for listening

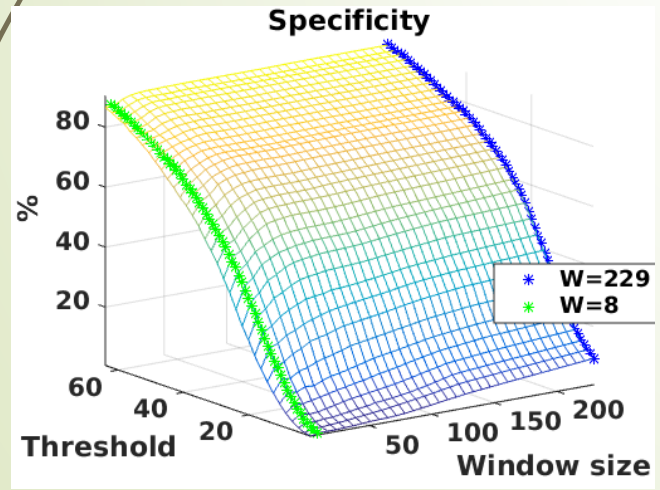


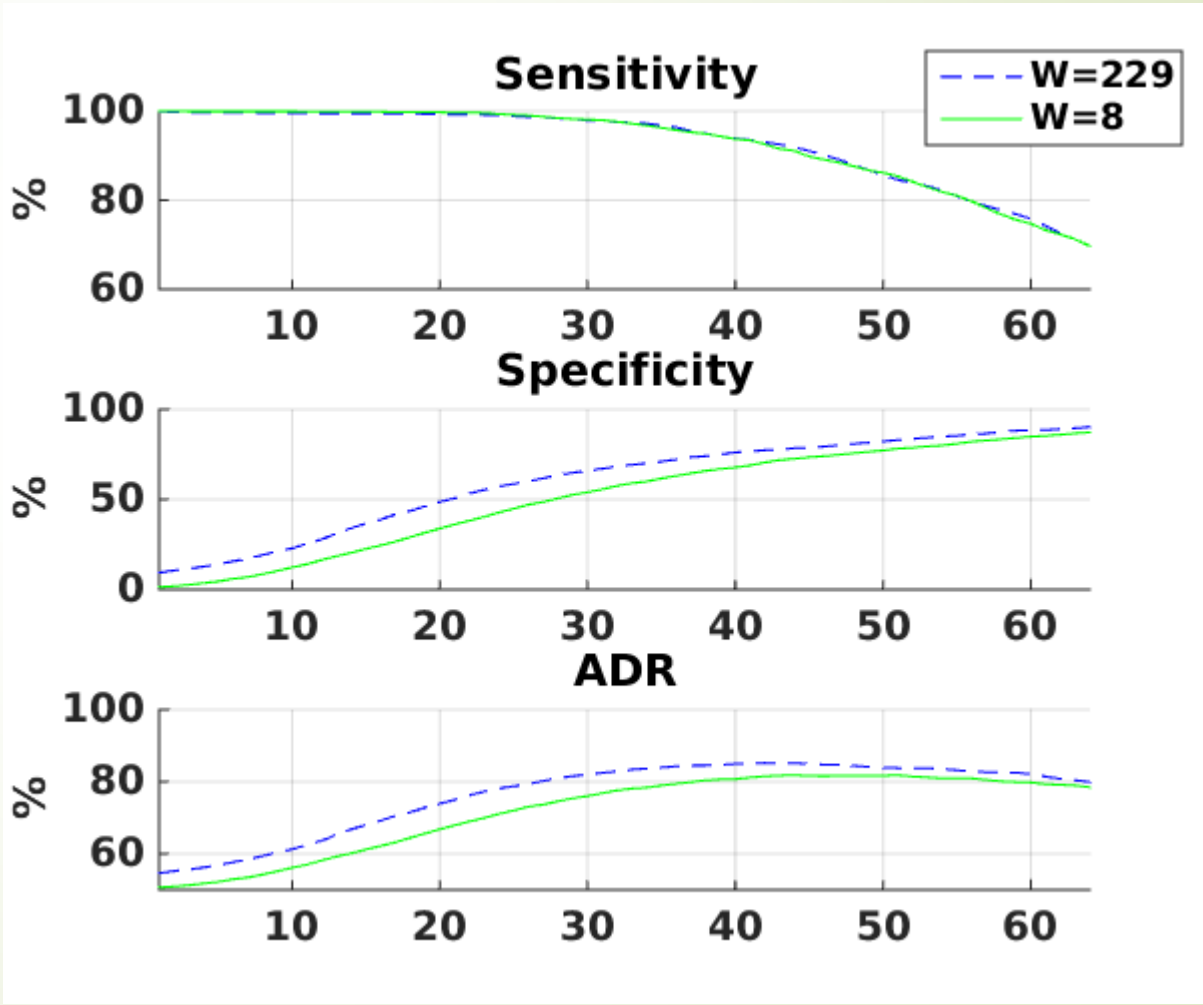
Project website:
**www.erasmusbrainproject.com**

# BACKUP SLIDES

# Threshold vs. Sensitivity & Specificity



# Threshold vs. Delay