Goal
Develop a real time sensor system to detect generalized tonic and tonic-clonic epileptic seizures. Epilepsy affects over 50 million people worldwide. Seizures like generalized tonic and generalized tonic-clonic can be life threatening. Tonic seizures are described as rigid, violent muscular contraction, fixing the limbs in some strained position. Figure 1 shows the electromyography (EMG) and accelerometer (ACC) signals during a mimicked tonic-clonic seizure.

Materials and setup
We used two sensor nodes (SN) from Shimmer, see figure 2.
- Sensitivity ACC: 800mV/g
- Frequency range EMG: 5-482Hz
- Gain: 682
- Max signal range: 4.4 mV
- Size: 53mm x 32mm x 25mm
- Weight: 22g
- Bluetooth connection
- Battery lifetime at 256Hz > 12h

The setup:
- 2 volunteers simulating 7 seizures
- SN on upper arms
- Input electrodes on Deltoids
- Reference electrode on Sternum
- Sample frequency: 256Hz
- Acquisition via EyesWeb & BioMo-bius

Signal processing
1. Highpass filter at 15 Hz for EMG and 1 Hz for ACC.
2. Onset detection on one EMG channel using Bonato method.
3. Eight features were computed using a sliding window of 2 seconds with 50% overlap.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Window Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Deviation</td>
<td>2 seconds</td>
</tr>
<tr>
<td>Root Mean Square</td>
<td>2 seconds</td>
</tr>
<tr>
<td>Zero Crossing Rate</td>
<td>2 seconds</td>
</tr>
<tr>
<td>Squared Integral (SI)</td>
<td>2 seconds</td>
</tr>
<tr>
<td>Median Frequency (up to 30Hz)</td>
<td>2 seconds</td>
</tr>
<tr>
<td>Max Frequency (6-30Hz)</td>
<td>2 seconds</td>
</tr>
<tr>
<td>Frequency Ratio (max(8-30Hz)/min(8-30Hz))</td>
<td>2 seconds</td>
</tr>
<tr>
<td>Waveform Length (WL)</td>
<td>2 seconds</td>
</tr>
</tbody>
</table>

4. WL for EMG was selected as most discriminant feature by exhaustive search and sequential forward selection.
5. Linear discriminant analysis (LDA) was used for classification. Two out of the seven simulated seizures are used to train the classifier.

Combined EMG/ACC classification
Figure 3 shows a diagram of EMG and ACC contributions for different physical activities. The SI is computed on the ACC channels for a sliding window of 16 samples, with 94% overlap. The max(SI) for ACC and WL for EMG in 2 seconds will be used further in analysis.

Results
The lower graph in figure 4 shows the detection results of both methods. In the upper graph (figure 4), the EMG signal from the right arm is plotted, with the simulated tonic seizures in red. The green part is a simulated tonic-clonic seizure. The middle graph shows the ACC channels of the right arm.

Conclusions
- A real time monitoring system was developed to record EMG and ACC data from patients. Patient data is being recorded using this system in Kempenhaeghe since October this year. Until now the patients in the trial did not have any relevant seizures for our goal.
- WL was found to be the best feature from the ones investigated for EMG.
- The combined EMG/ACC method shows superior results compared with LDA.

Future work:
- Account for packet loss in the Bluetooth transmission. Implement the algorithm in real-time in Matlab. Validate the algorithm with patient data.