COST Action - FP1005

joint

5nd MC/WG Meeting

5th ERCOFTAC SIG43 Workshop

“Fibre suspension flow modelling - a key for innovation and competitiveness in the pulp & paper industry”

6-8 March, 2013, Coimbra, Portugal

DEEC/FCT and DEQ/FCTUC
University of Coimbra
Portugal

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Characterization of fibres flow using EIT: recent developments

Presentation Outline

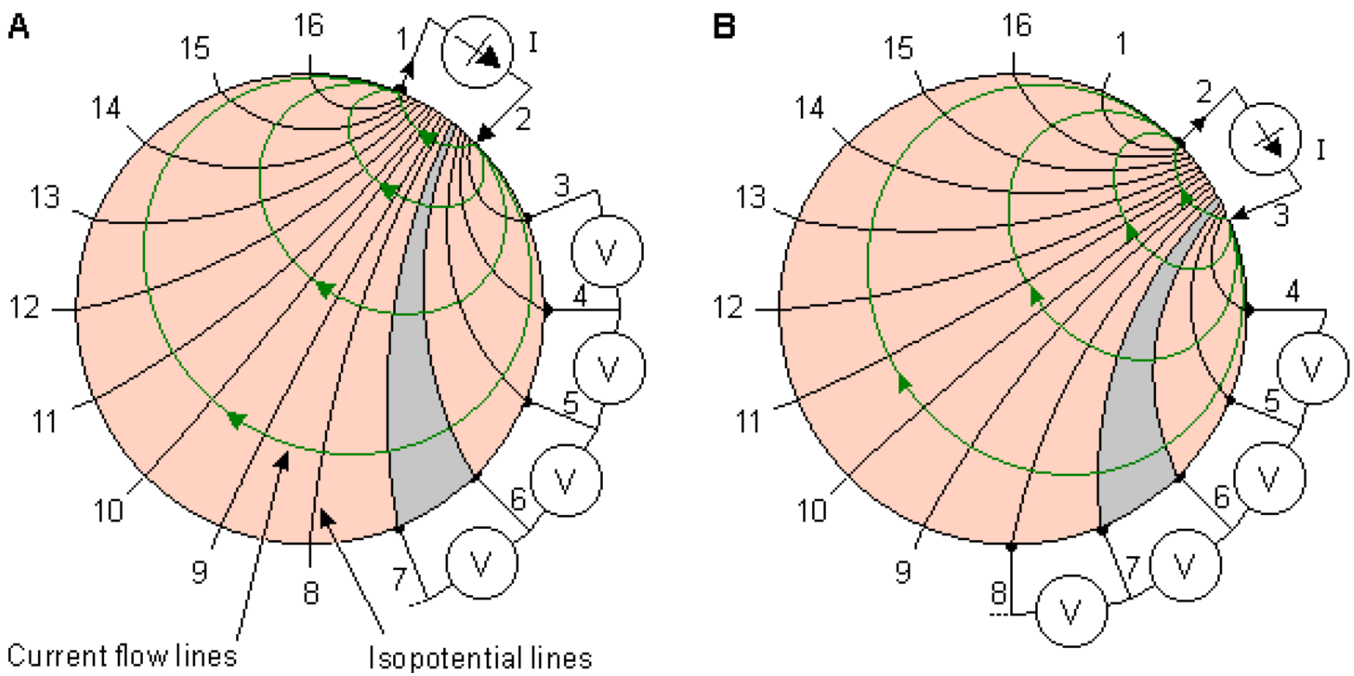
- Brief Introduction to Electrical Impedance Tomography.
- Pulp Fibres characterization:

  A) Difficulties found.

  B) Solutions proposed.

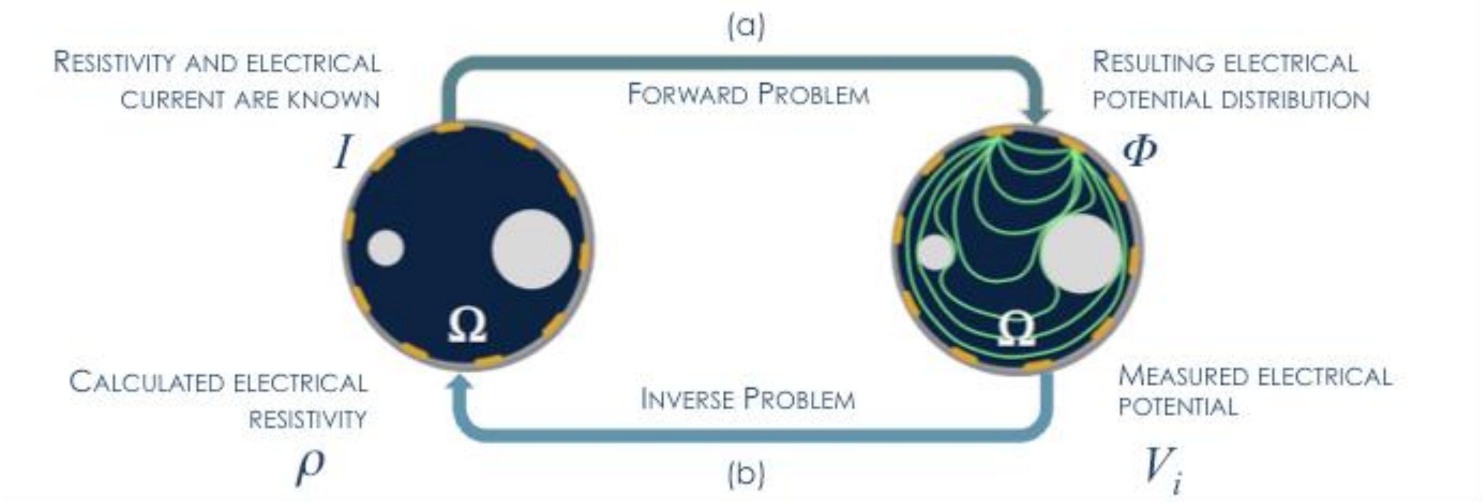
Electrical Impedance Tomography overview

In the development of accurate models for suspension related processes, prior knowledge of several flow characteristics is essential, such as spatial distribution of phases, flow regimen, interfacial area, and relative velocity between phases, amongst others.



Mathematical Formulation

Complete Electrode Model (CEM)



Regularized Gauss-Newton algorithm

For all described tests a mesh with 2304 triangular elements and 1201 nodes was used.

Majorly opposite injection and adjacent measuring was used.

First Step

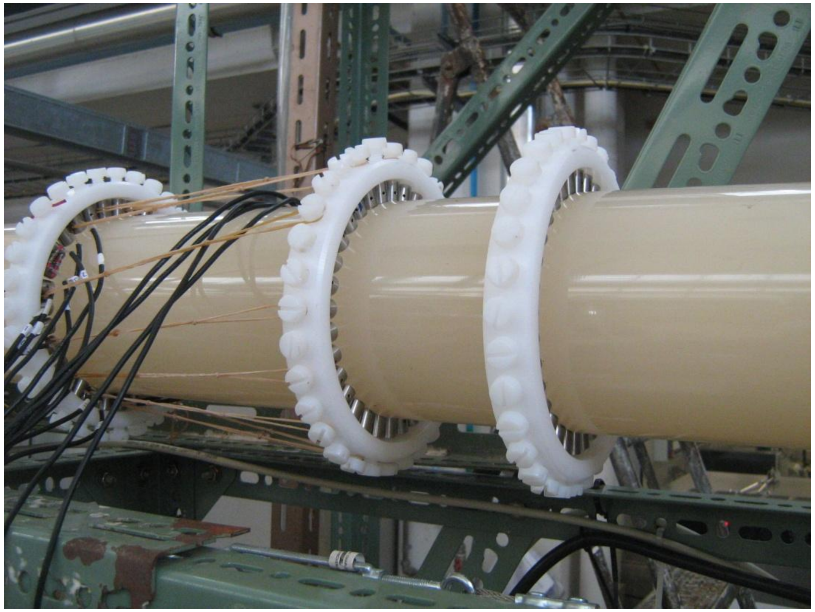
Problem identification

Paper Fibres behaviour function of liquid medium adsorption process.

Pilot Rig Tests

and

Offline tests



Constant flow testing

For the tests depicted, Eucalyptus short fibres suspended in industrial water, with a length of 0,706±0,03 mm, and with an initial concentration of ± 2.67 % (m/m) was used: several dilutions were made, and diverse flow velocities were also set.

Reference medium:

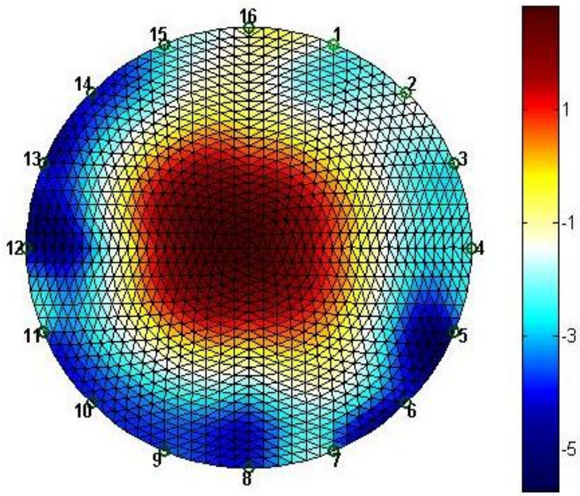
For Exp 1 and 2, industrial water with conductivity 1197 mS/cm^2;

For Exp 3, NaCl doped water with conductivity 940 μS/cm^2;

Inside rig section of 0.157 m^2.

	Exp 1	**Exp 2**	**Exp 3**
Velocity (m/s)	1	2	2
Concentrations (m/m)	2.67, 2.37, 2, and 1.6%	2.67, 2.37, 2, and 1.6%	2.67, 2.37, 1.6, and 1.3%

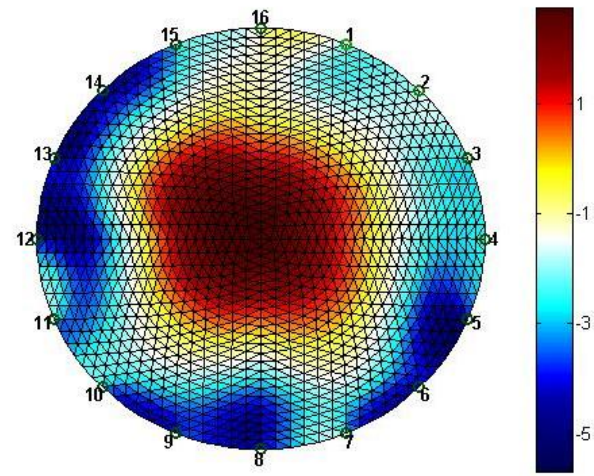
Constant flow testing



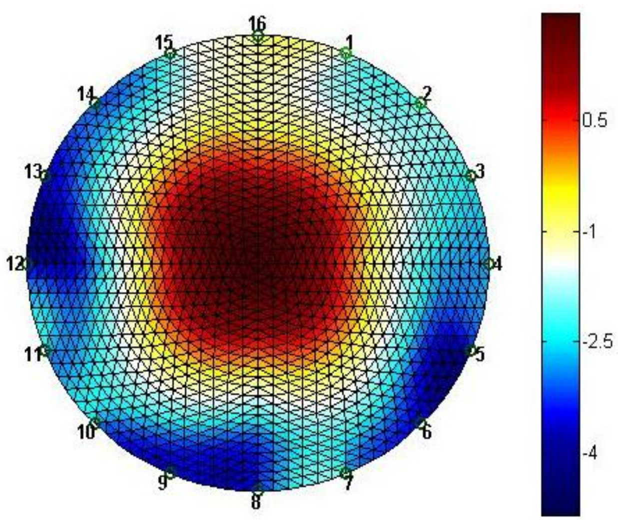
Exp 1

Concentration 2.67%

Exp 2



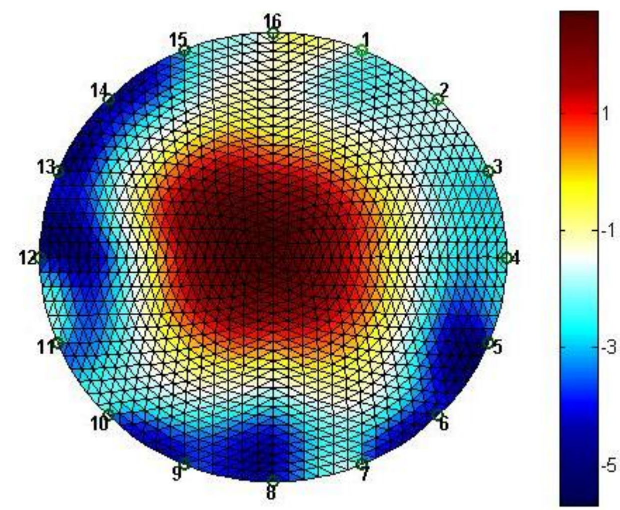
Applied excitation $2V_{pp}$ at 2KHz



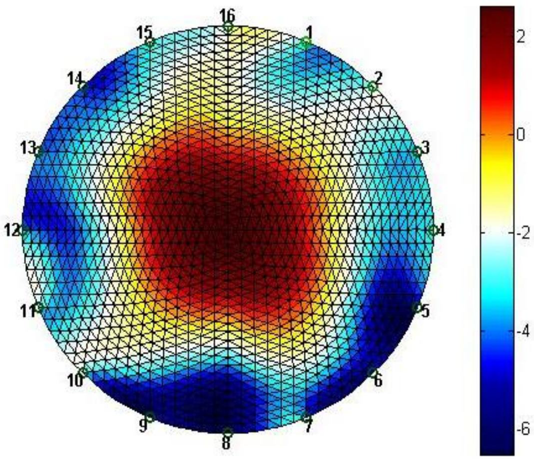
Exp 1

Concentration 2.37%

Exp 2



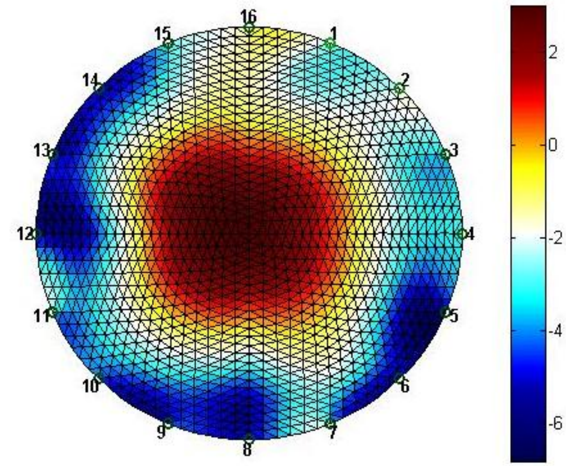
Constant flow testing



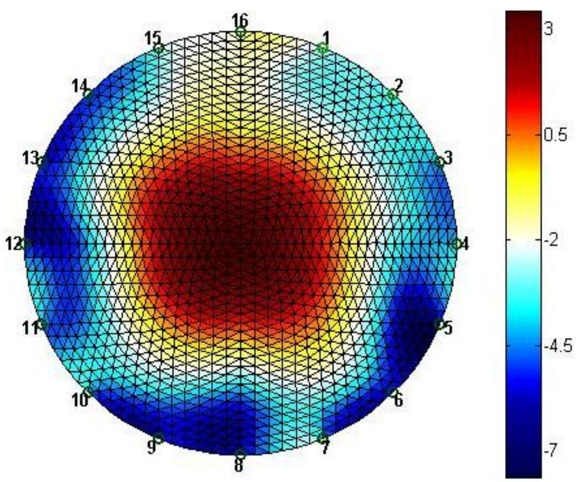
Exp 1

Concentration 2%

Exp 2



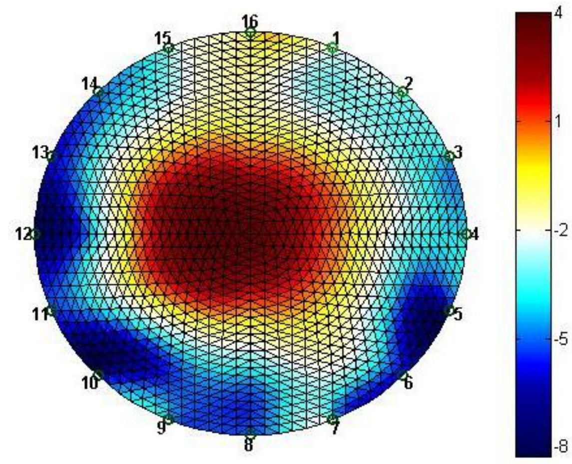
Applied excitation $2V_{pp}$ at 2KHz



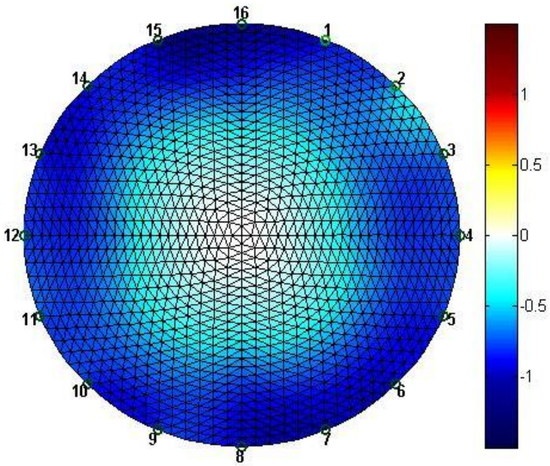
Exp 1

Concentration 1.6%

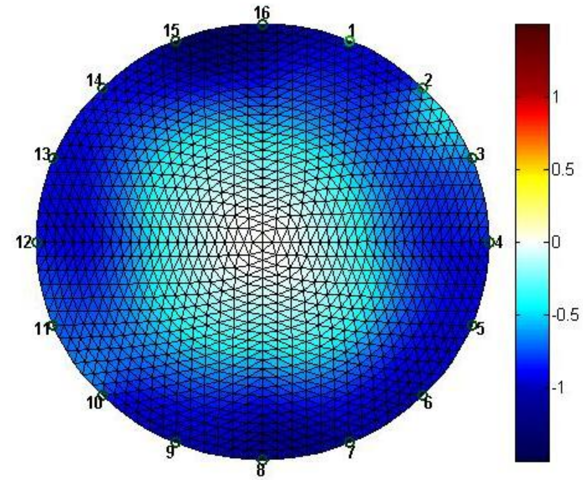
Exp 2



Constant flow testing



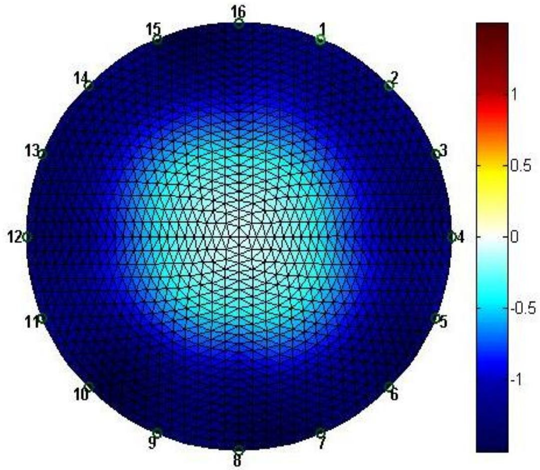
2.67 % concentration



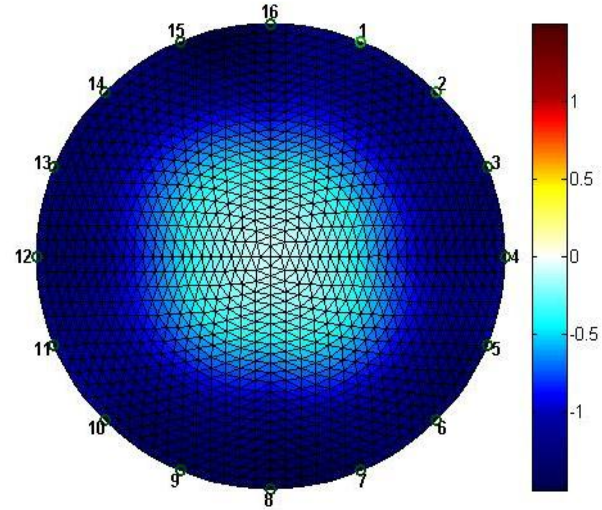
2.37 % concentration

Exp 3

Applied excitation $2V_{pp}$ at 2KHz



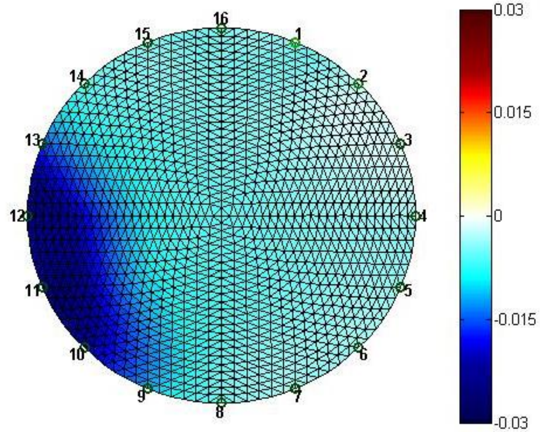
1.6 % concentration



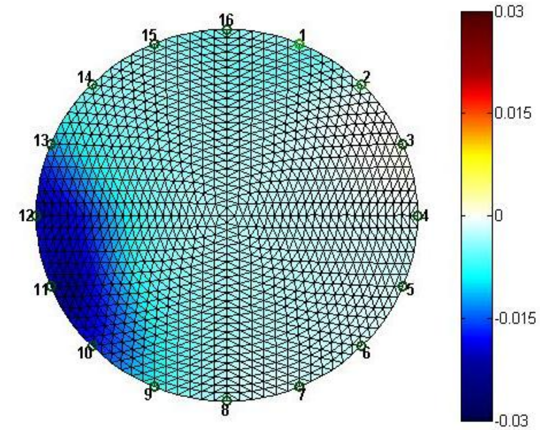
1.3 % concentration

Offline testing
(stainless steel electrodes section)

Kraft tube with a thickness of 2mm and 25mm in diameter in water.

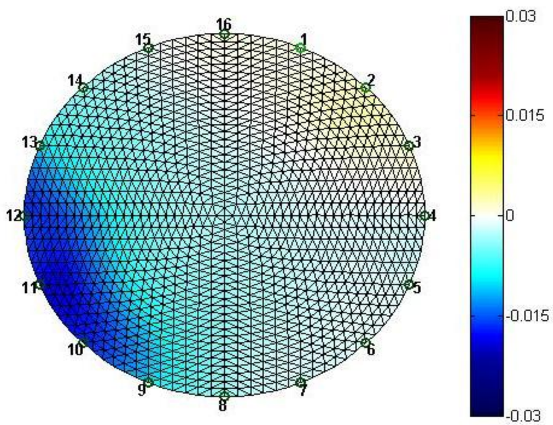


Time = 0s

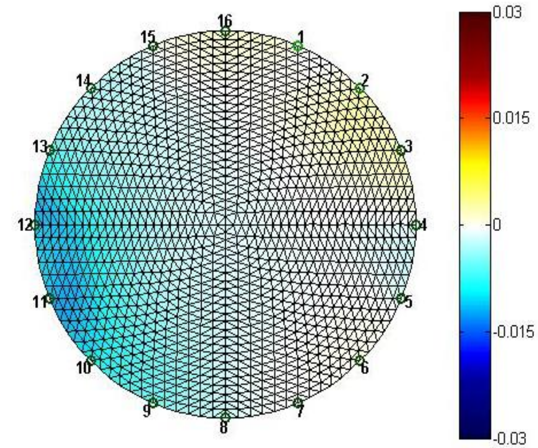


Time = 60s

Applied excitation $2V_{pp}$ at 2KHz



Time = 300s



Time = 420s

Second Step

Problem identification

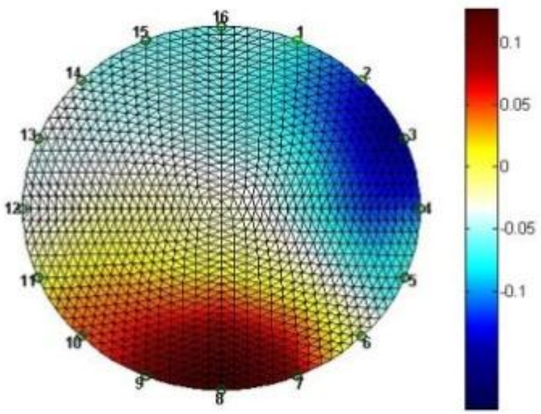
Industrial pulp fibres behaviour using diverse reference mediums.

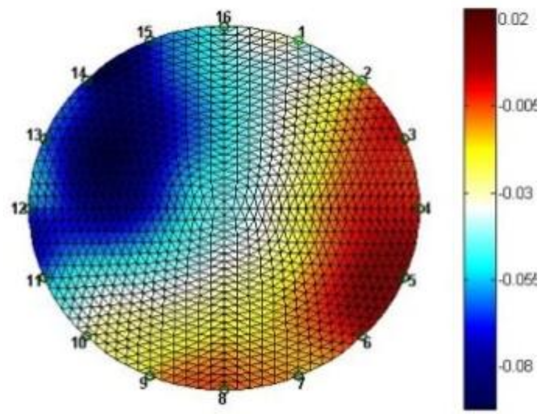
Offline testing

Offline testing
(stainless steel electrodes section

Pulp fibres, with a conductivity of 29.8 µS/cm², introduced in a Kraft tube with a thickness of 2mm and 25mm in diameter, in a (Applied excitation: $2V_{pp}$ at 2KHz).

Reference Medium: water with a conductivity of 6.4 µS/cm²

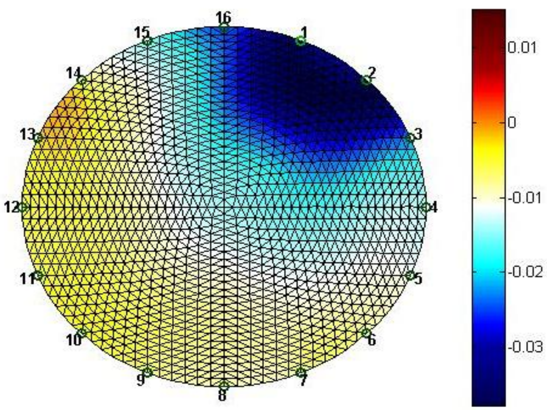


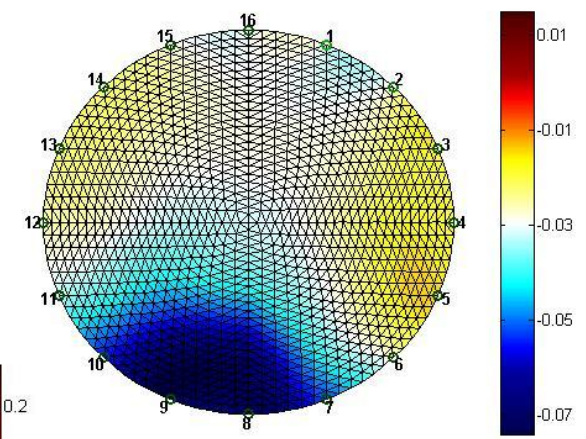


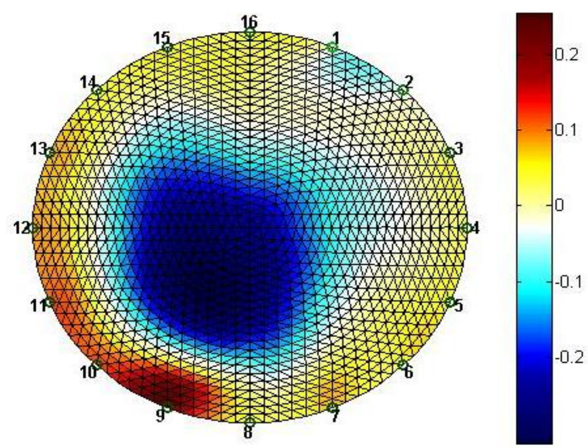
Offline testing (stainless steel electrodes section)

Pulp fibres, with a conductivity of 29.8 µS/cm², introduced in a Kraft tube with a thickness of 2mm and 25mm in diameter (Applied excitation: $2V_{pp}$ at 2KHz).

Reference Medium: NaCl doped water with a conductivity of 990 µS/cm²



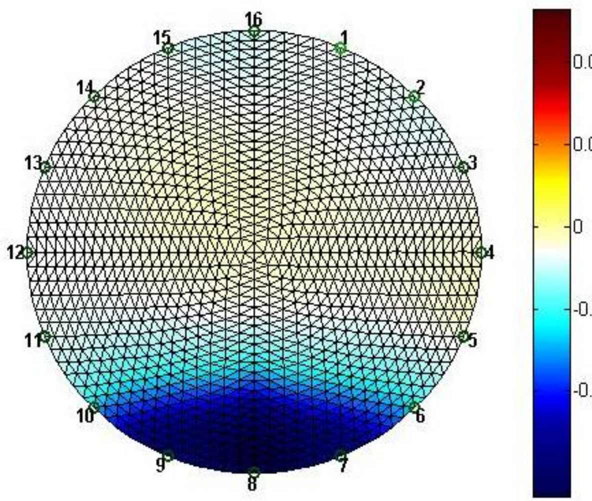


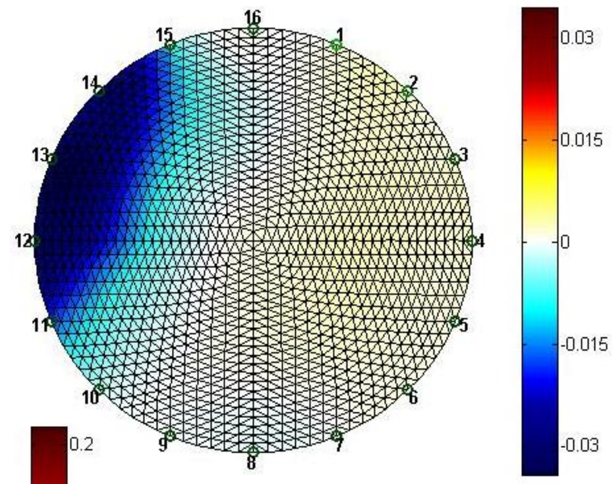


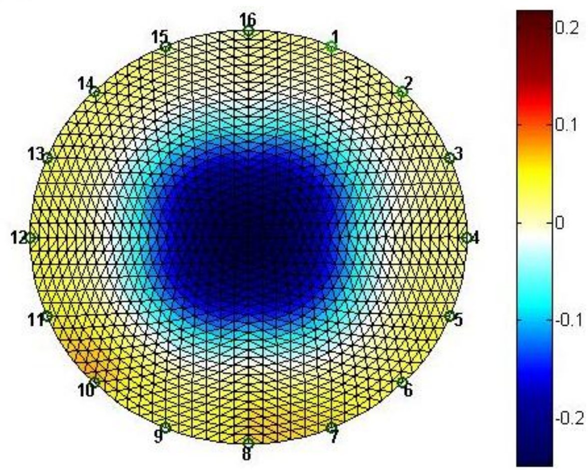
Offline testing
(2.5 mm titanium electrodes section)

Pulp fibres, with a conductivity of 31.3 µS/cm², introduced in a Kraft tube with a thickness of 2mm and 25mm in diameter (Applied excitation: 2V_{pp} at 2KHz).

Reference Medium: NaCl doped water with a conductivity of 1.8 mS/cm²



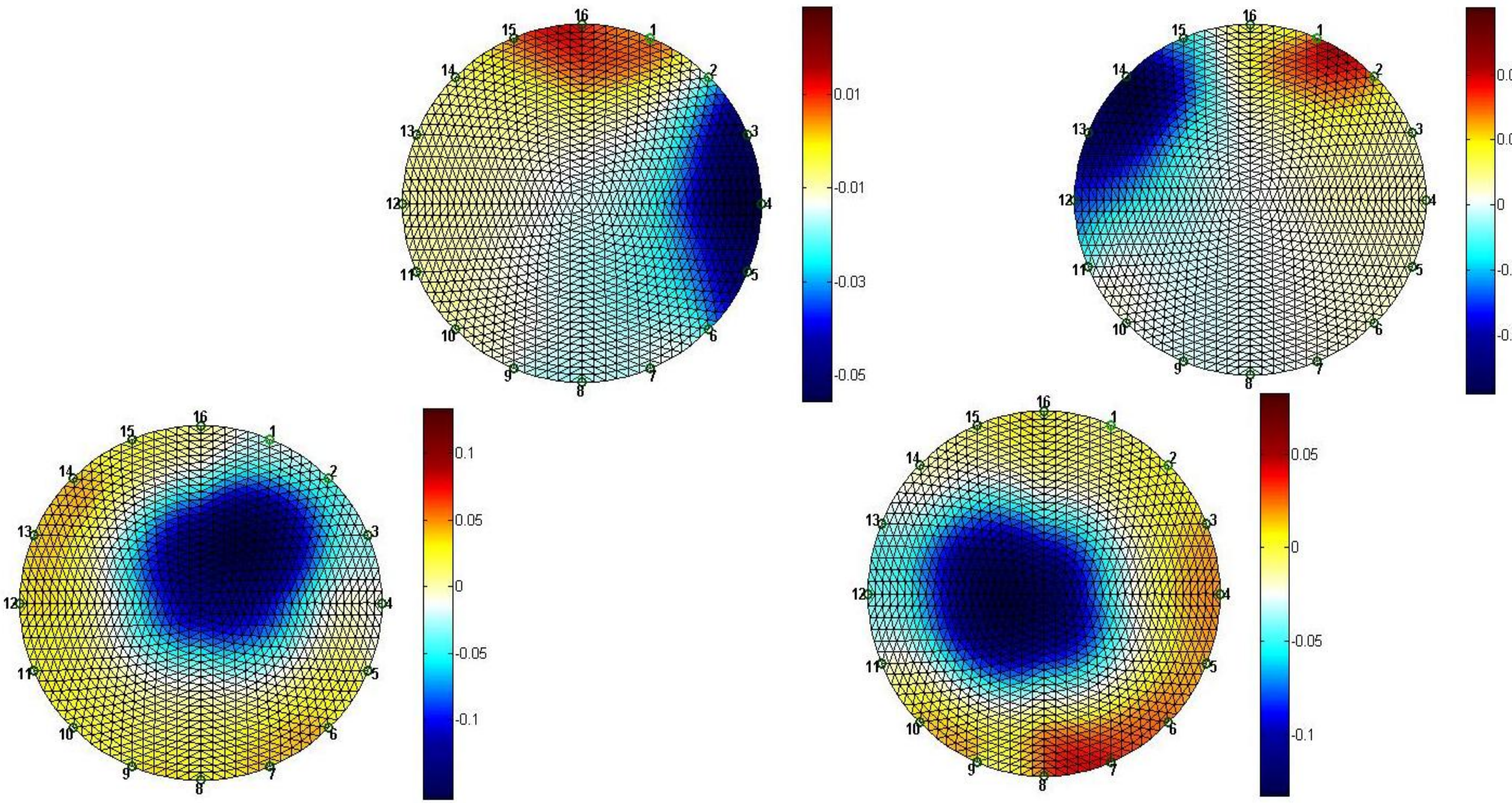




Offline testing
(2.5 mm titanium electrodes section)

Pulp fibres, with a conductivity of 52.4 µS/cm², introduced in a Kraft tube with a thickness of 2mm and 25mm in diameter (Applied excitation: $2V_{pp}$ at 2KHz).

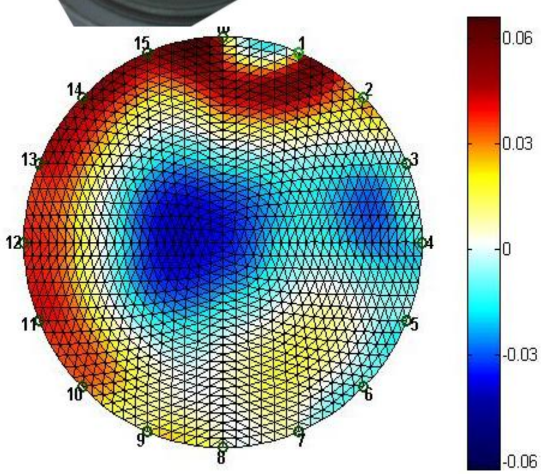
Reference Medium: NaCl doped water with a conductivity of 1.8 mS/cm²



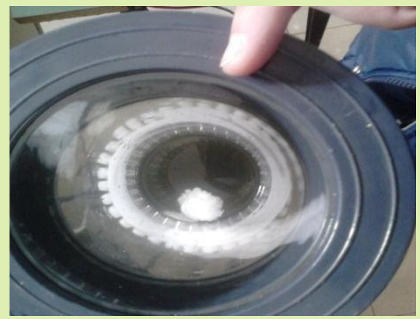
Offline testing
(2.5 mm titanium electrodes section)

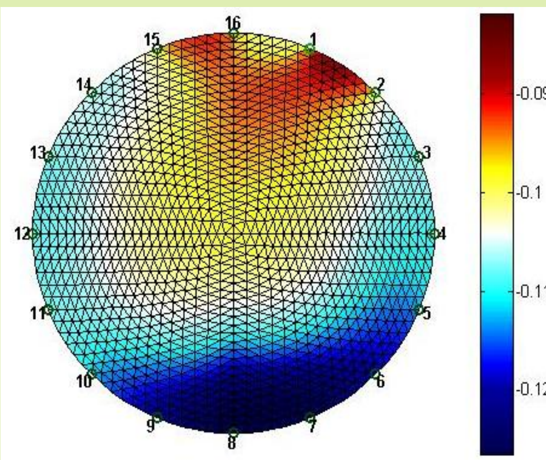
Bunch of fibres in suspension (Applied excitation: $2V_{pp}$ at 2KHz).

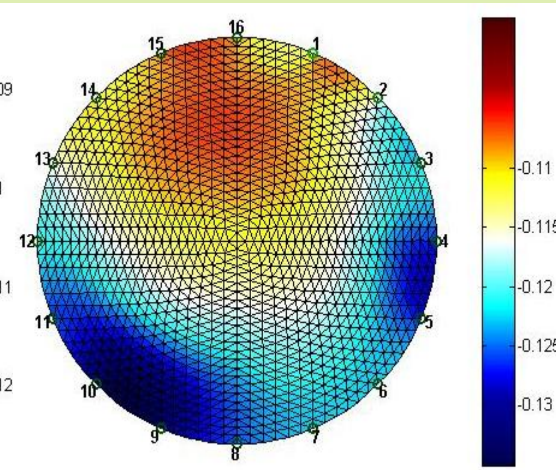
Non washed fibres : reference Medium is NaCl doped water with a conductivity of 1.8 mS/cm²



Washed fibres : reference Medium is NaCl doped water with a conductivity of 550 µS/cm²







Third Step

Ways to address the identified problem

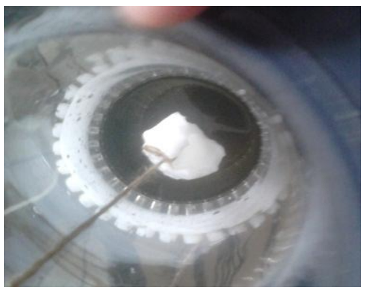
Industrial pulp fibres behaviour using diverse reference mediums
and
EIT sensitivity operation frequency optimization.

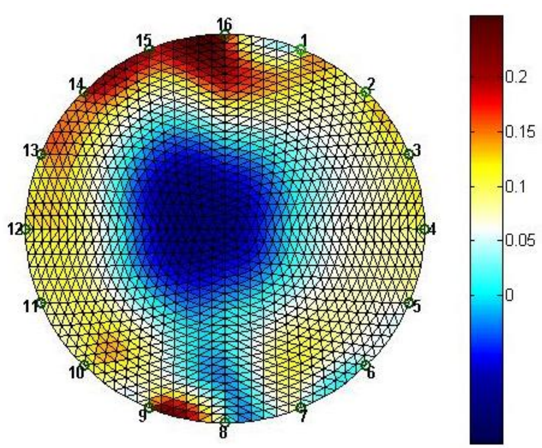
Offline testing

Offline testing
(2.5 mm titanium electrodes section)

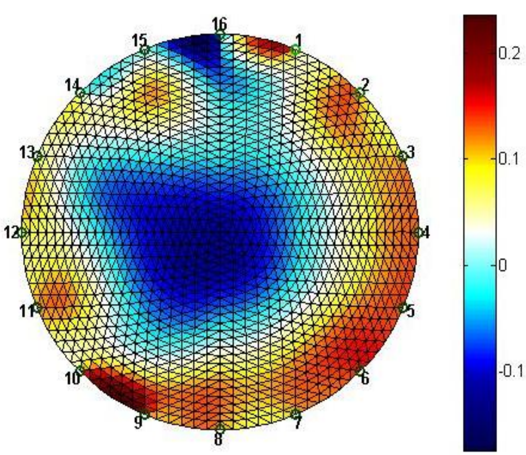
Industrial pulp fibres, with a conductivity of 52.4 µS/cm², introduced in a lint (Applied excitation: $2V_{pp}$ at 2KHz).

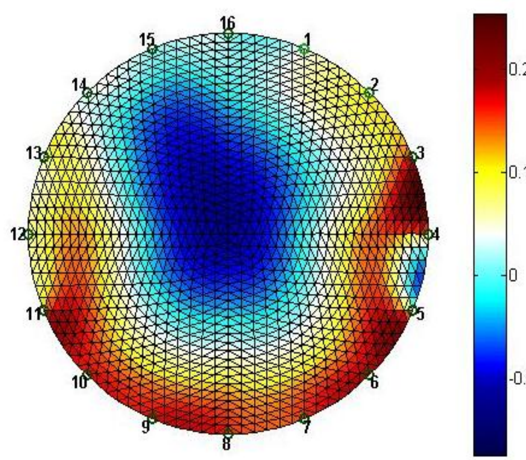
Reference Medium: NaCl doped water with a conductivity of 550 µS/cm²





Reference Medium: NaCl doped water with a conductivity of 1.1 mS/cm²



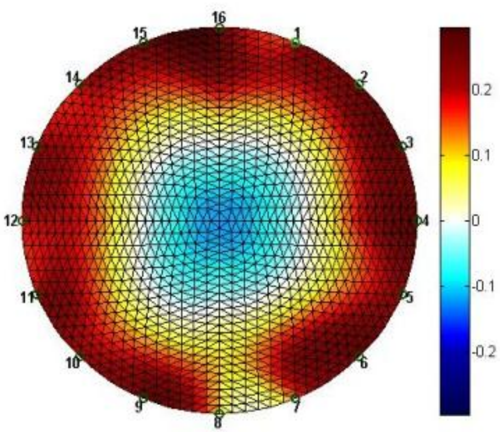


Offline testing (2.5 mm titanium electrodes section)

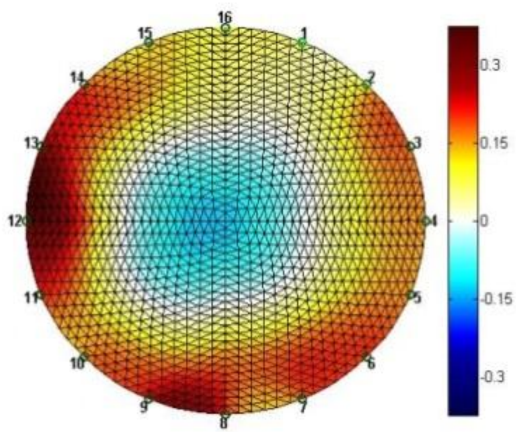
Industrial pulp washed fibres, with a conductivity of 58 µS/cm^2, introduced in a lint (Applied excitation: 2V$_{pp}$ at 2, 10 and 20 KHz).

Reference Medium: NaCl doped water with a conductivity of 403 µS/cm^2

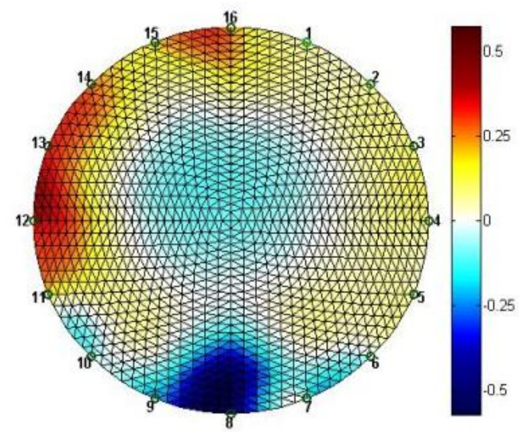
2 KHZ



10 KHZ



20 KHZ

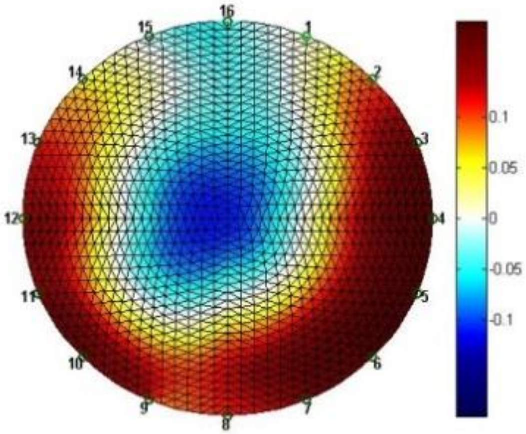


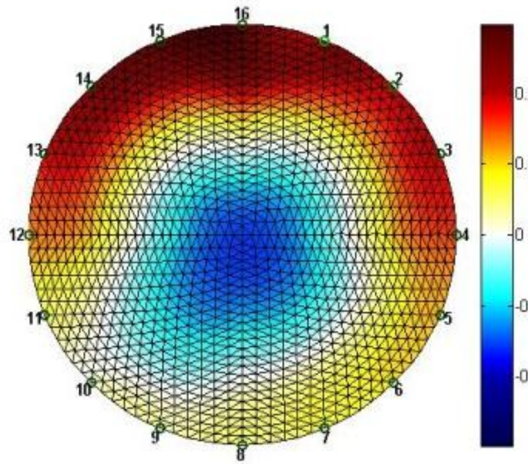
Offline testing
(2.5 mm titanium electrodes section)

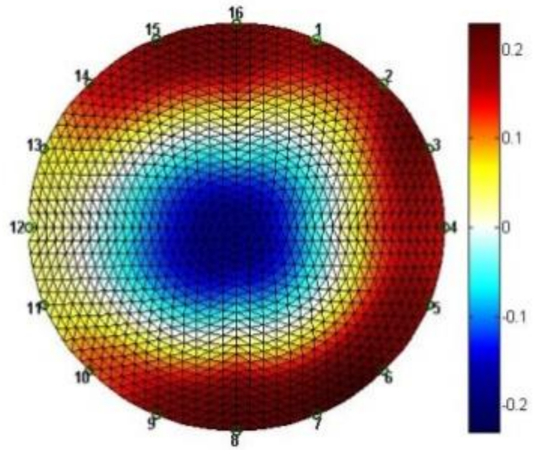
Industrial pulp washed fibres, with a conductivity of 58 µS/cm², introduced in a lint (Applied excitation: 2V_{pp} at 2, 10 and 20 KHz).

Reference Medium: NaCl doped water with a conductivity of 1.4 mS/cm²

2 KHZ | **10 KHZ** | **20 KHZ**





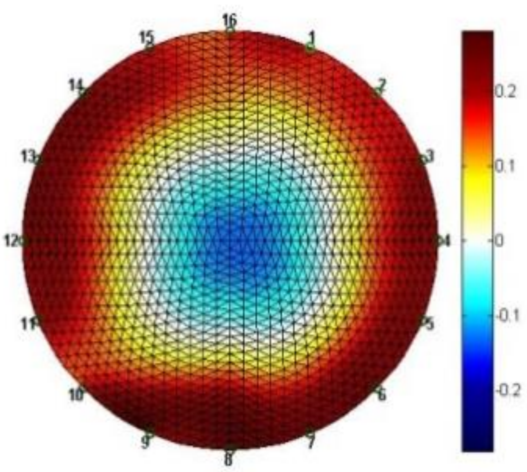


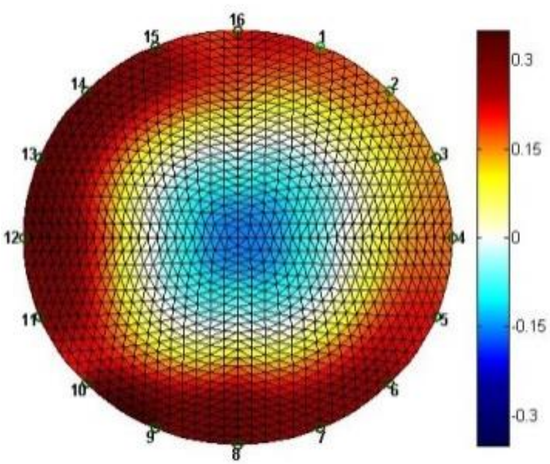
Offline testing
(2.5 mm titanium electrodes section)

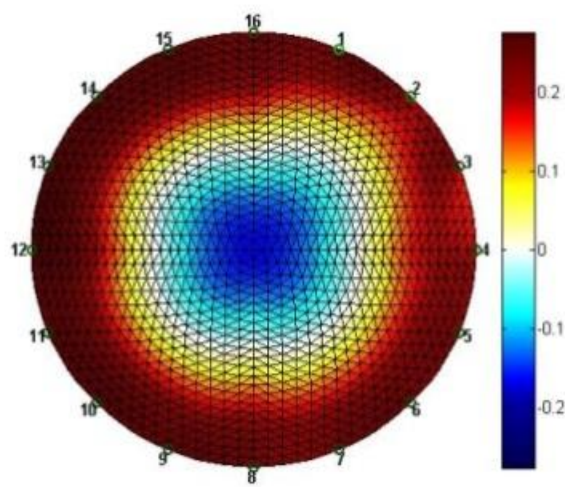
Industrial pulp fibres introduced in a lint (Applied excitation: $2V_{pp}$ at 2, 10 and 20 KHz).

Reference Medium: NaCl doped water with a conductivity of 1.4 mS/cm²

2 KHZ	10 KHZ	20 KHZ





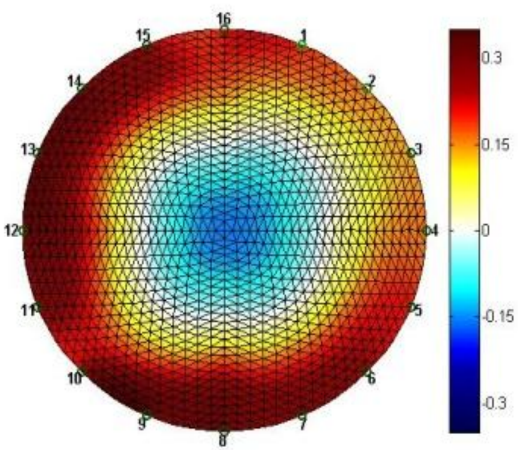


Offline testing
(2.5 mm titanium electrodes section)

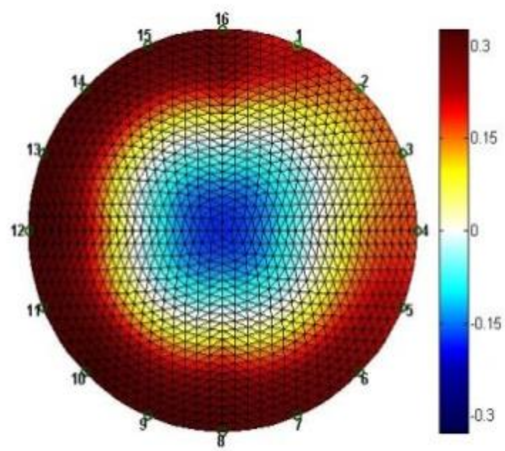
Industrial pulp fibres introduced in a lint (Applied excitation: $2V_{pp}$ at 10KHz).

Reference Medium: NaCl doped water with a conductivity of 1.4 mS/cm^2

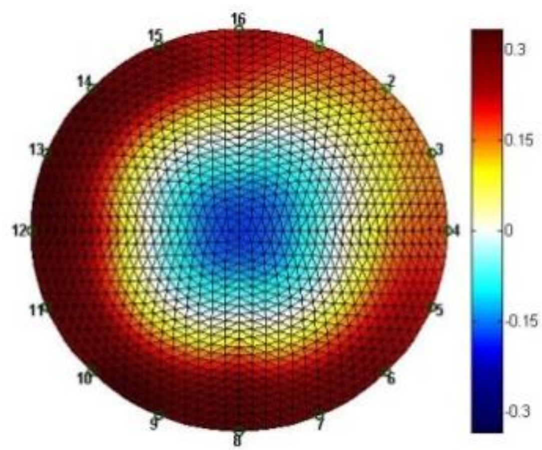
Time = 0s



Time = 300s



Time = 600s



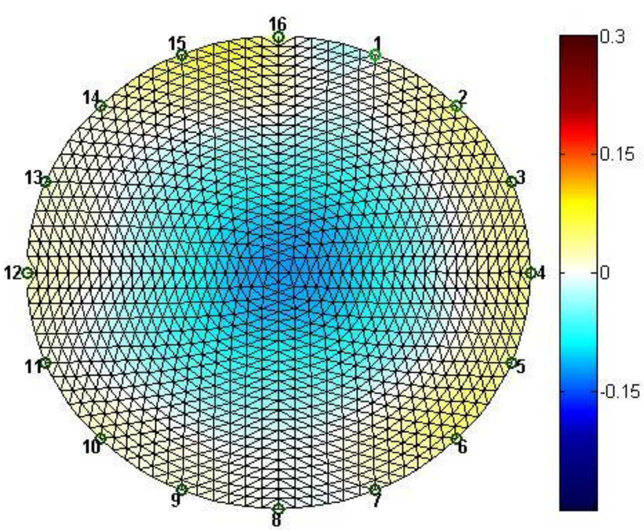
Offline testing (stainless steel electrodes section)

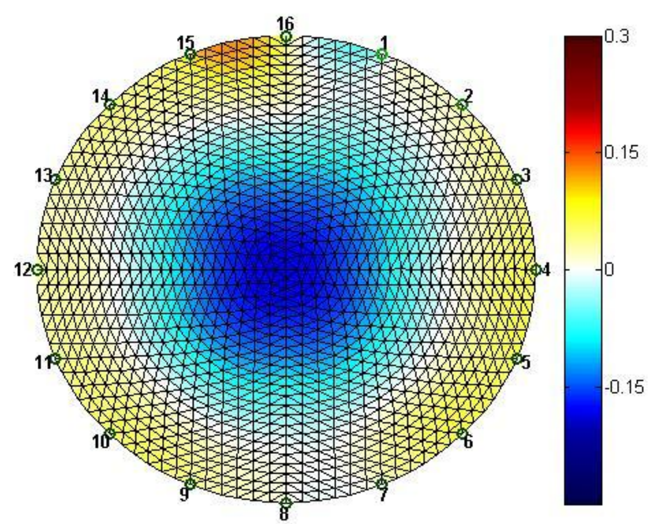
Industrial pulp fibres and industrial pulp washed fibres introduced in a lint (Applied excitation: $2V_{pp}$ at 2KHz).

Reference Medium: NaCl doped water with a conductivity of 1.144 mS/cm^2

Non Washed

Washed/Squeezed



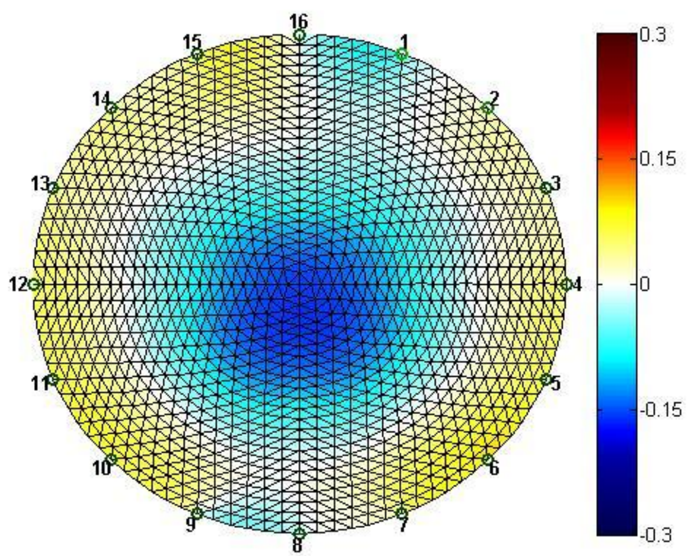


Offline testing (stainless steel electrodes section)

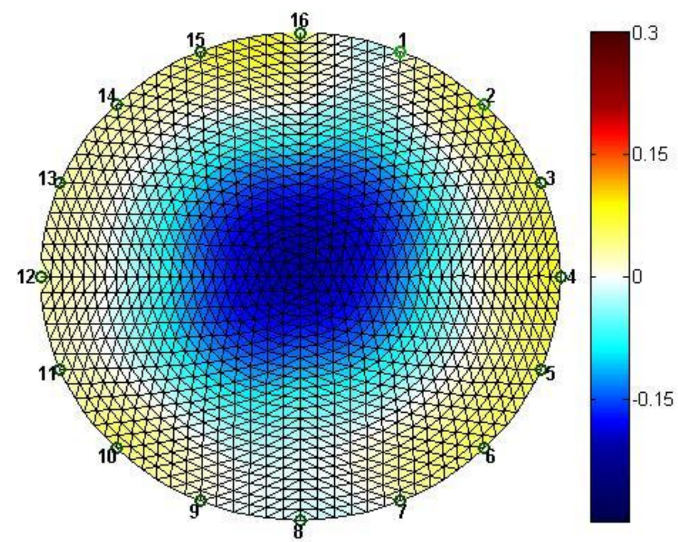
Industrial pulp fibres and industrial pulp washed fibres introduced in a lint (Applied excitation: $2V_{pp}$ at 10KHz).

Reference Medium: NaCl doped water with a conductivity of 1.144 mS/cm²

Non Washed



Washed/Squeezed



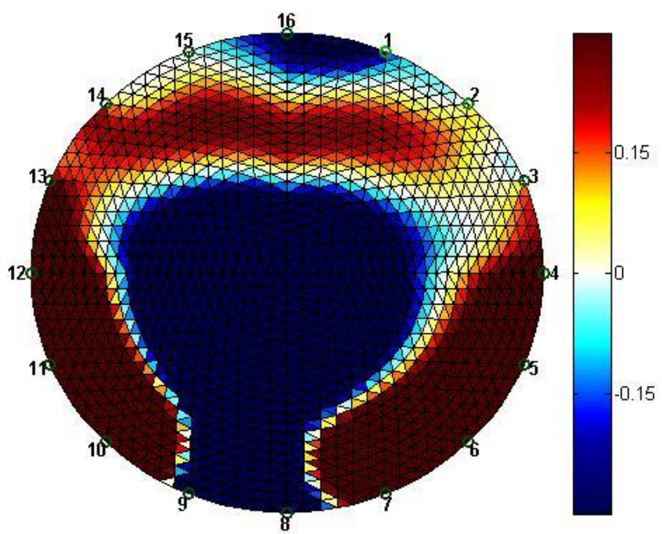
Offline testing (stainless steel electrodes section)

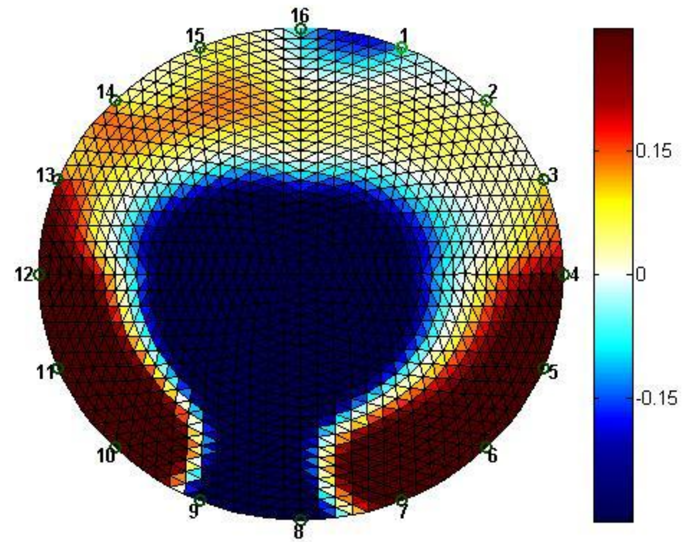
Industrial pulp fibres and industrial pulp washed fibres introduced in a lint (Applied excitation: $2V_{pp}$ at 20KHz).

Reference Medium: NaCl doped water with a conductivity of 1.144 mS/cm²

Non Washed

Washed/Squeezed



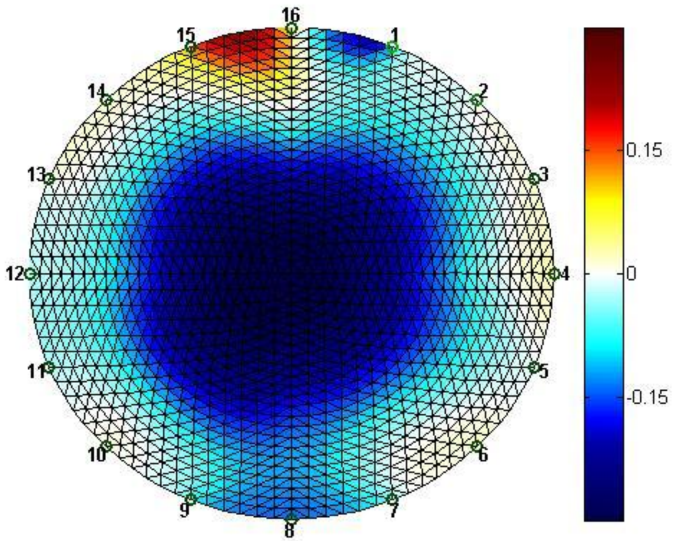


Offline testing (stainless steel electrodes section)

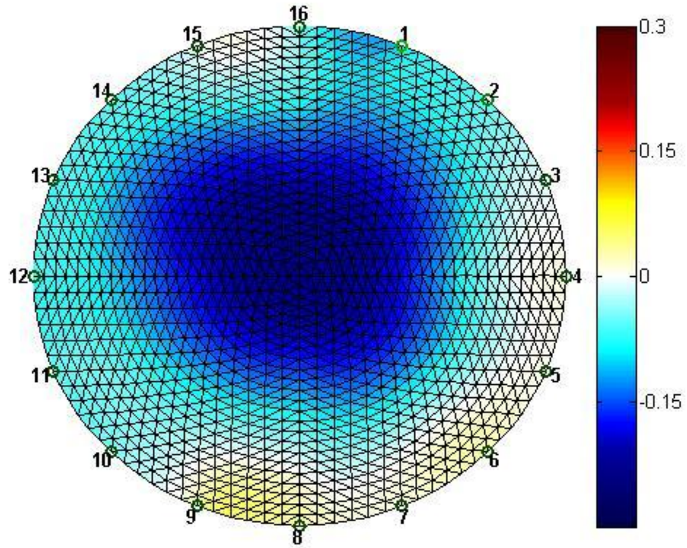
Industrial pulp fibres and industrial pulp washed fibres introduced in a lint (Applied excitation: $2V_{pp}$ at 2KHz).

Reference Medium: Industrial water with a conductivity of 1.056 mS/cm²

Non Washed



Washed/Squeezed

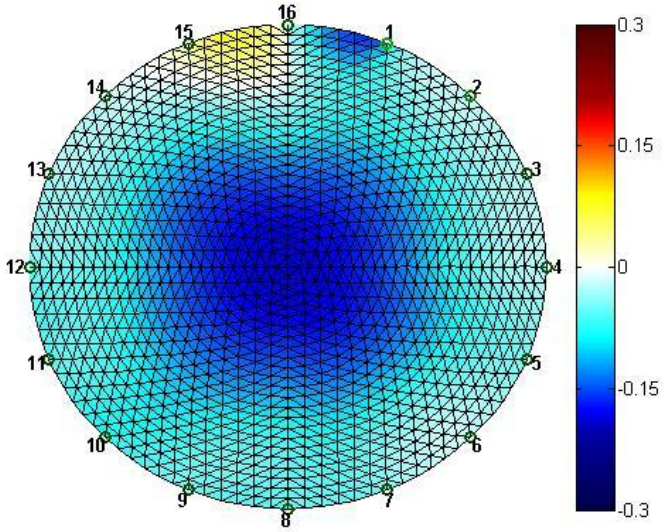


Offline testing
(stainless steel electrodes section)

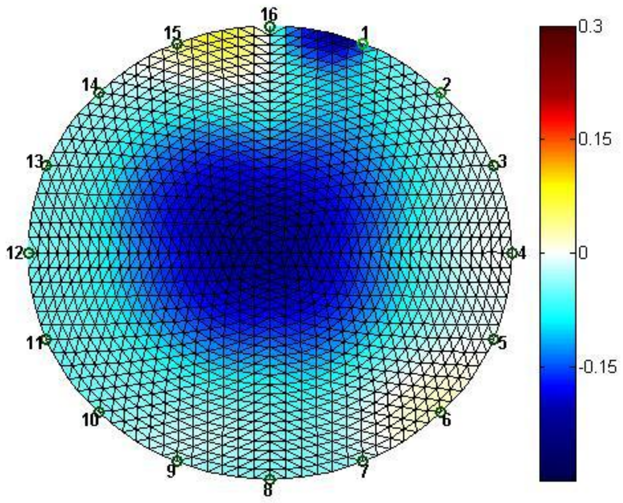
Industrial pulp fibres and industrial pulp washed fibres introduced in a lint (Applied excitation: 2V_{pp} at 10KHz).

Reference Medium: industrial water with a conductivity of 1.056 mS/cm²

Non Washed



Washed/Squeezed

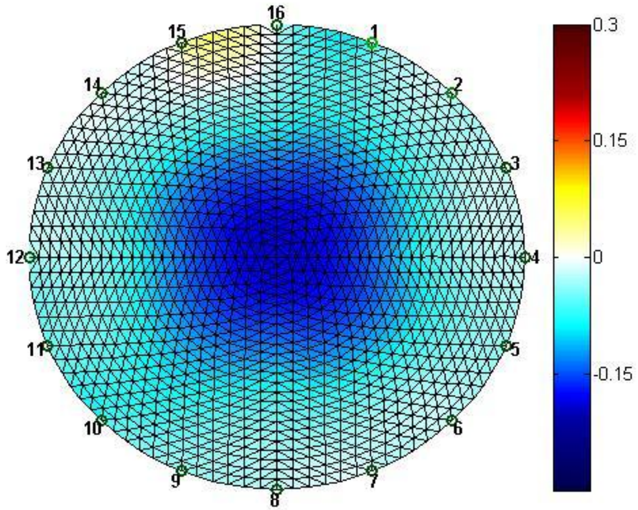


Offline testing
(stainless steel electrodes section)

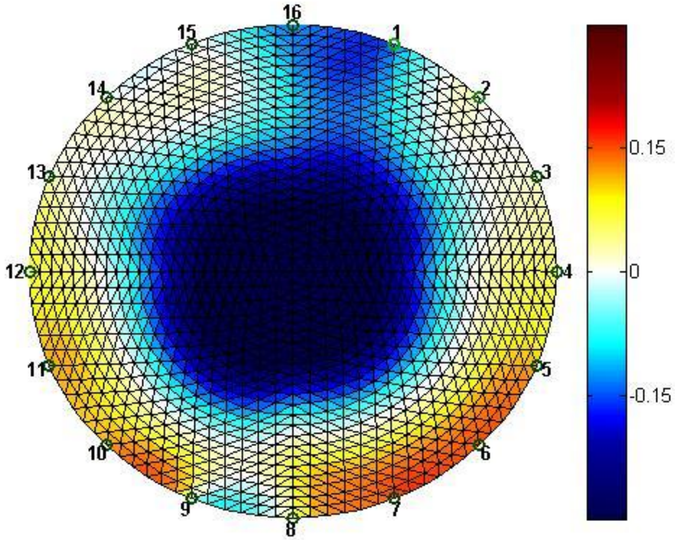
Industrial pulp fibres and industrial pulp washed fibres introduced in a lint (Applied excitation: $2V_{pp}$ at 20KHz).

Reference Medium: industrial water with a conductivity of 1.056 mS/cm²

Non Washed



Washed/Squeezed

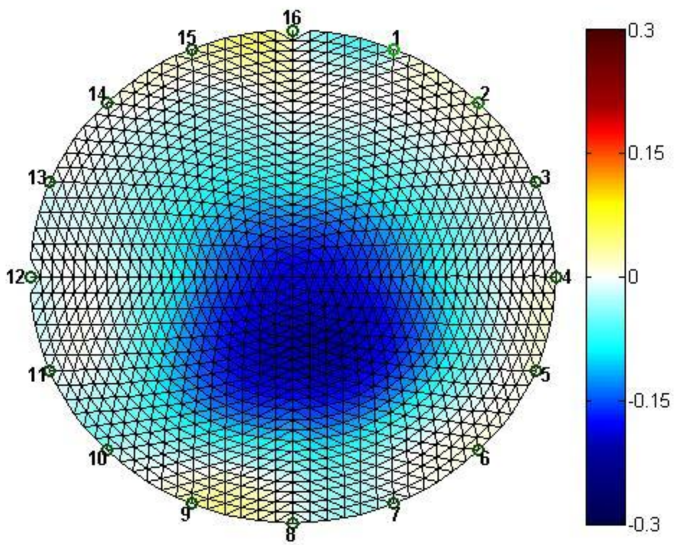


Offline testing
(stainless steel electrodes section)

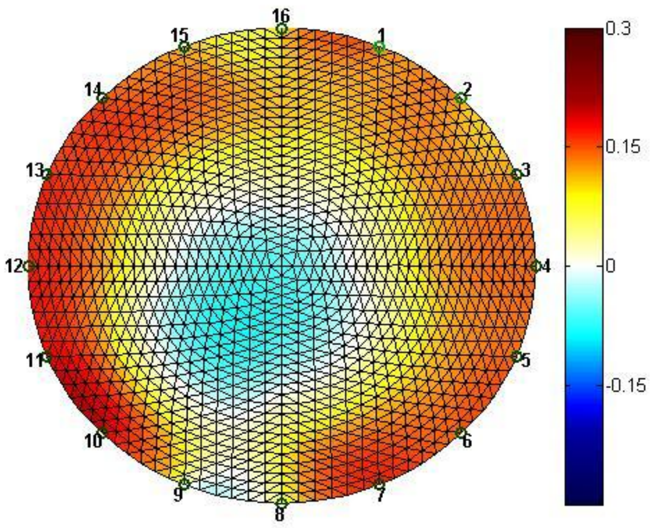
Industrial pulp fibres and industrial pulp washed fibres introduced in a lint (Applied excitation: $2V_{pp}$ at 2KHz).

Reference Medium: NaCl doped water containing suspended washed fibres with a conductivity of 1.2 mS/cm²

Non Washed



Washed/Squeezed

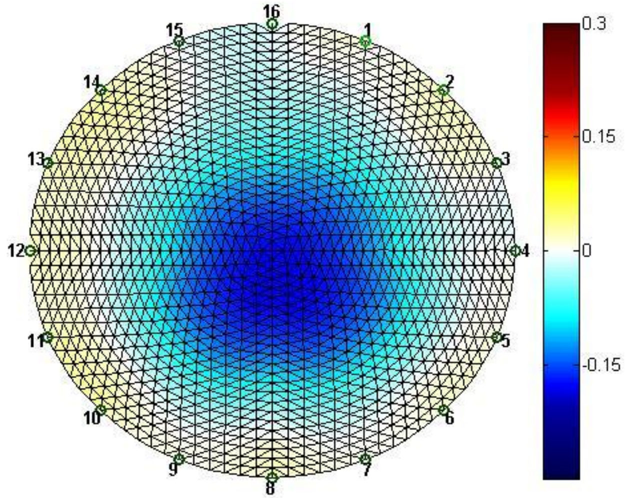


Offline testing (stainless steel electrodes section)

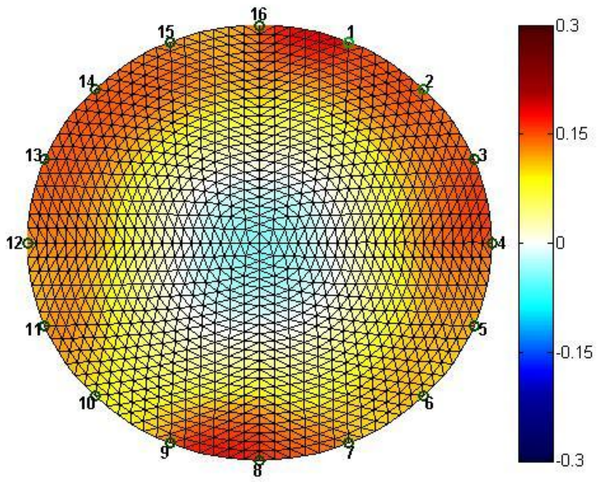
Industrial pulp fibres and industrial pulp washed fibres introduced in a lint (Applied excitation: $2V_{pp}$ at 10KHz).

Reference Medium: NaCl doped water containing suspended washed fibres with a conductivity of 1.2 mS/cm²

Non Washed



Washed/Squeezed

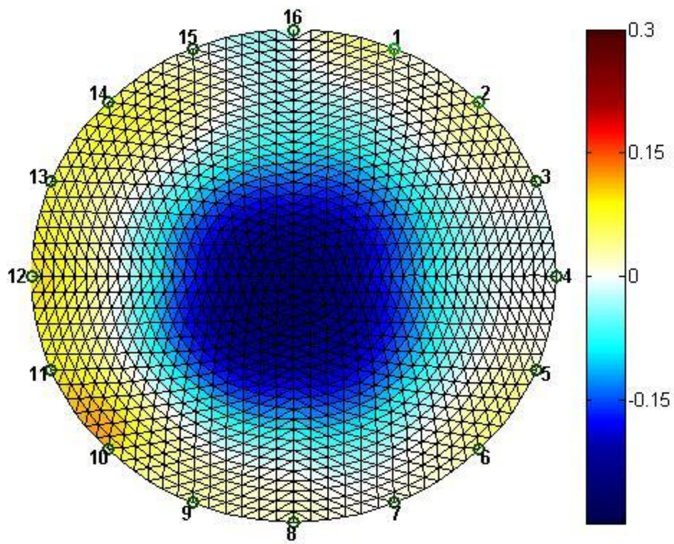


Offline testing
(2.5 mm stainless steel electrodes section)

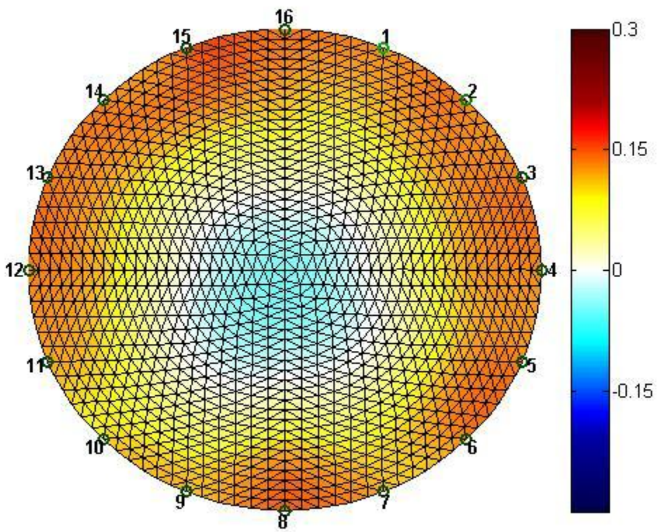
Industrial pulp fibres and industrial pulp washed fibres introduced in a lint (Applied excitation: $2V_{pp}$ at 20KHz).

Reference Medium: NaCl doped water containing suspended washed fibres with a conductivity of 1.2 mS/cm^2

Non Washed



Washed/Squeezed



Next steps

- For test in the pilot rig:

a) Fibres will be squeezed;

b) NaCl doped water will be used as reference solution medium, instead of the industrial water that comes with the pulp fibres (conductivity around 1 mS/m^3);

c) Applied excitation frequency used will be 10 KHz.

- Other type of fibres, for instance pine, will be tested.

Thank you
for you attention