

# MIBRASCAN

## HEAD PHANTOM GENERATION : A 3D printed structure filled of liquid mixtures

1

NADINE JOACHIMOWICZ UP7

BERNARD DUCHÊNE CNRS

OLIVIER MEYER UP6

DOMINIQUE PICARD CENTRALESUPELEC

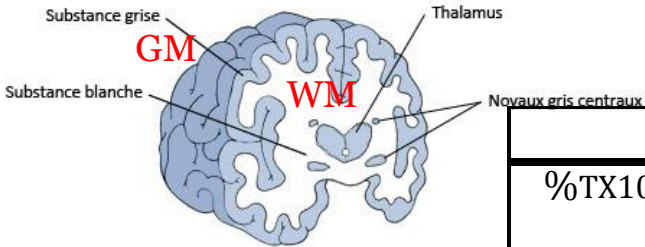


CentraleSupélec



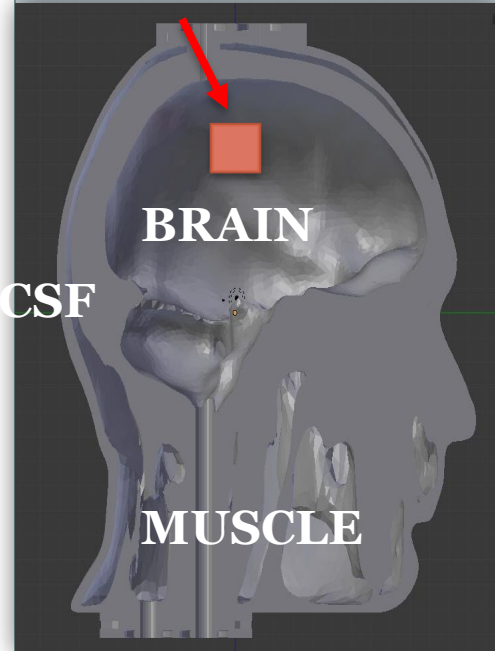
# PIERS 2015 : the various biological tissues are mimicked by adjusting salted water % using Böttcher's binary mixture law

2



BRAIN = 0.3 GM + 0.7 WM

ANOMALY = Blood



OPTIMISATION @ T=37°C [500 MHz - 6GHz] values @ 2.45 GHz

%TX100	99	74	58	45	38	37.2	37.8
	G3	Bone	Lung	Nerve	WM	G2	Skin
Salt g/L	0	1	4	3	3	3.4	4.5
$\epsilon_r$ Böttcher	5.18	11.28	20.38	30.26	36.39	36.99	36.24
	Debye	5.14	11.36	20.44	30.1	36.27	37.06
$\sigma$ (S/m)	0.22	0.41	0.83	0.97	1.09	1.13	1.28
	Debye	0.14	0.41	0.82	1.11	1.28	1.48

%TX100	27	24	20	19.5	13.7	4
	G1	GM	Muscle	T	Blood	CSF
Salt g/L	4	4.6	4	4.6	7.5	11.5
$\epsilon_r$ Böttcher	46.38	48.86	52.57	53.2	57.91	65.8
	Debye	46.61	48.83	52.67	58.18	66.17
$\sigma$ (S/m)	1.42	1.55	1.48	1.61	2.26	3.2
	Debye	1.58	1.84	1.67	1.82	2.59

# EuCAP 2017 : ajustement of salt and TritonX100 concentrations for UWB head phantom, comparison with measured values @1.5 GHz



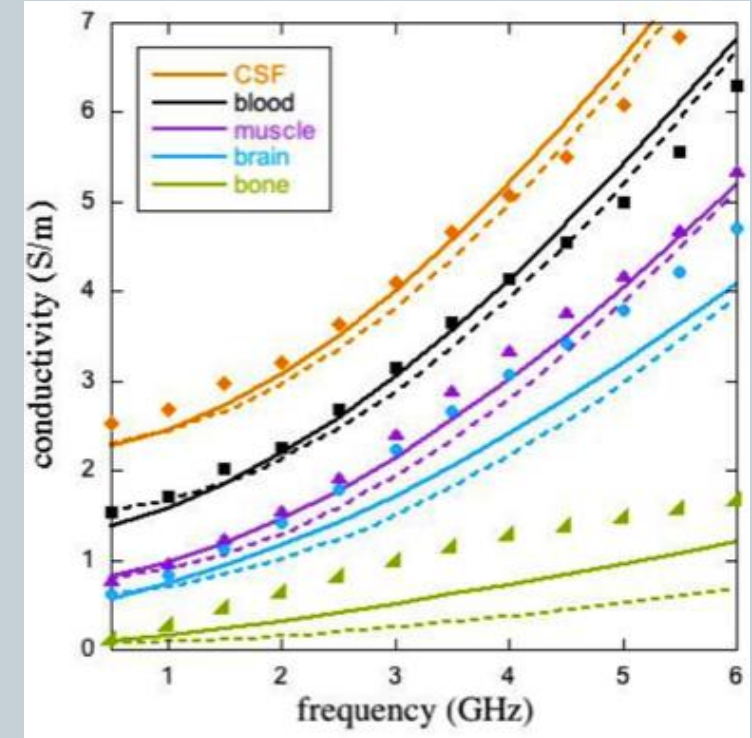
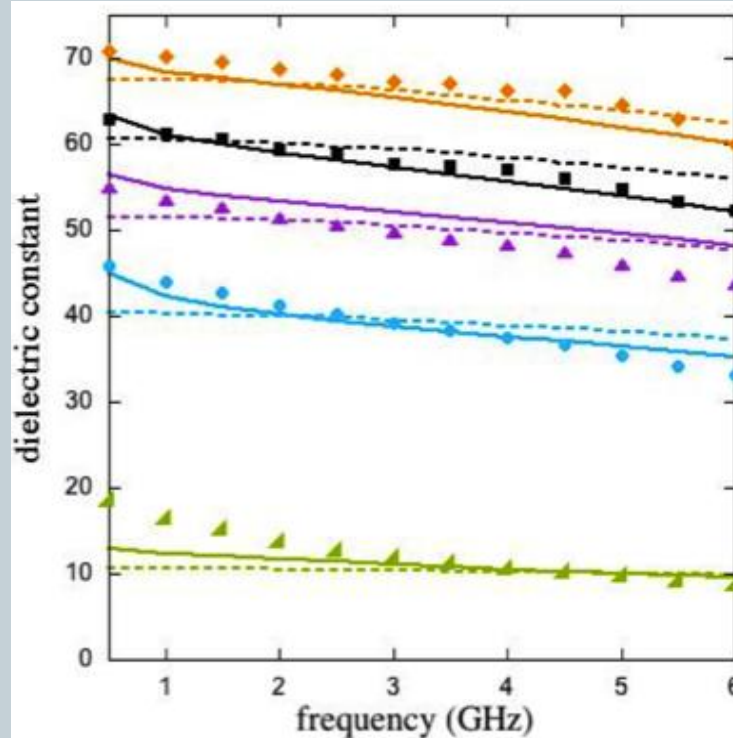
<i>Tissue</i>	<i>mixture</i>		<i>measurements</i>		<i>Cole-Cole model</i>	
	<i>TX-100 (vol %)</i>	<i>NaCl (g/L)</i>	$\epsilon_r$	$\sigma$ (S/m)	$\epsilon_r$	$\sigma$ (S/m)
Brain	38	5.2	43	1.1	40	1.2
CSF	6	13.7	69	2.9	68	2.7
Muscle	24	5.0	53	1.2	54	1.2
Bone	75	0.8	15	0.5	12	0.2
Blood	14	9.4	61	2.0	60	1.9

# EXPERIMENTAL VALIDATION HEAD PHANTOM [500 MHz-6 GHz]

8



Agilent 85070E



••• measured values  
 — Cole-Cole model  
 - - - Bötcher's law

# HEAD PHANTOM GENERATION,

## The 3D printed structure as written in the proposal

5

**Task 1** “Selection of test cases and segmentation”: the CT/MRI images will be selected and segmented in order to generate numerical phantoms

**Task 2** “Numerical phantom generation” & “Physical phantoms design and building”

**Task 3** ”Design and realization of 3D anthropomorphic head phantoms”

# HEAD PHANTOM GENERATION

First see, what it is possible to build ?

6

**Task 1** Design a head phantom with cavities from the STL file downloaded from [http://phantoms.martinos.org/Main\\_Page#Filling](http://phantoms.martinos.org/Main_Page#Filling) , as done for the breast phantom

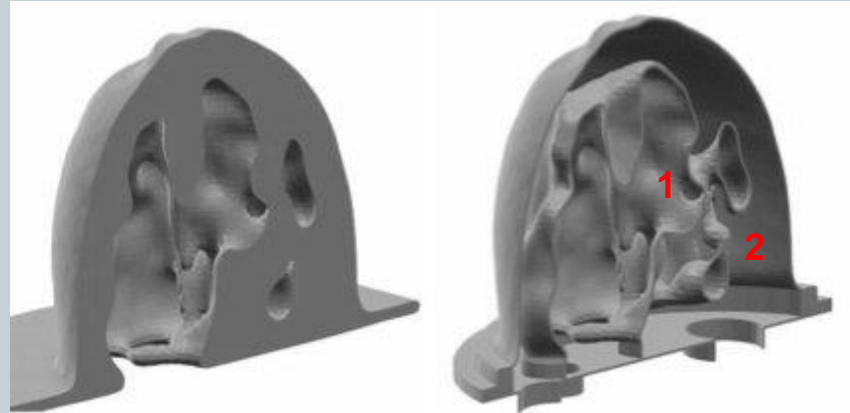
**Task 2** Generate a numerical phantom from the modified STL file

**Task 3** Design and realization of 3D anthropomorphic head phantoms

# 3D PRINTED PHANTOMS

7

original



modified

breast

breast

<https://uwcem.ece.wisc.edu/phantomRepository.html>

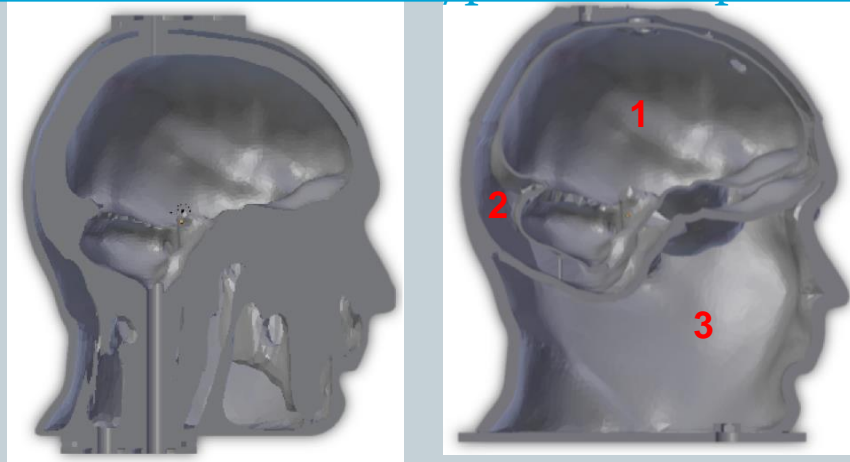
and

and

head

head

phantoms

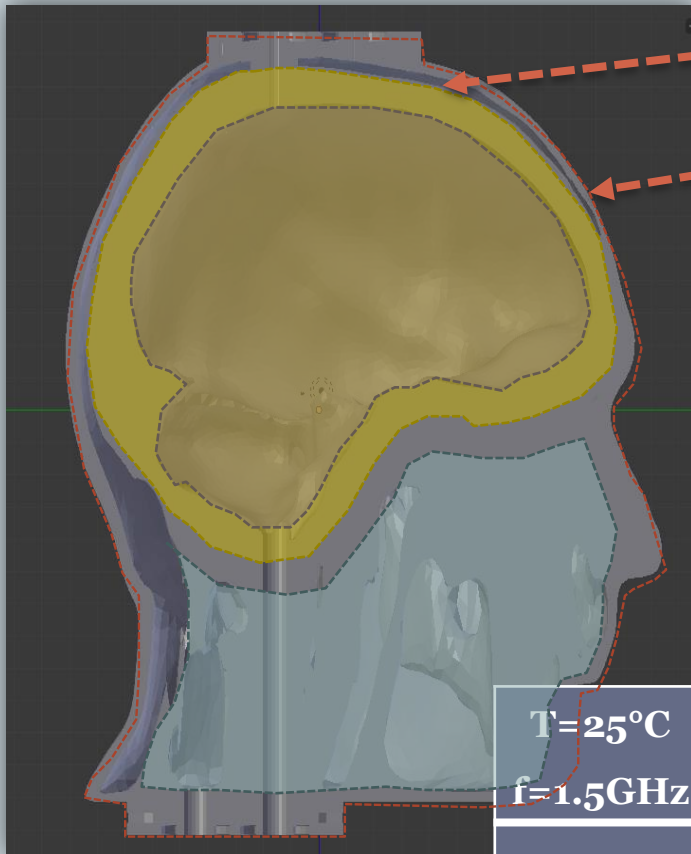


phantoms

[http://phantoms.martinos.org/Main\\_Page#Filling](http://phantoms.martinos.org/Main_Page#Filling)

# Task1.2 SUGGESTION : 3 CAVITIES, the Design

8



SKULL

SKIN

BRAIN WM+GM+Cerebellum y 1

CSF

MUSCLE

ABS

Cavit

Cavity 2

Cavity 3

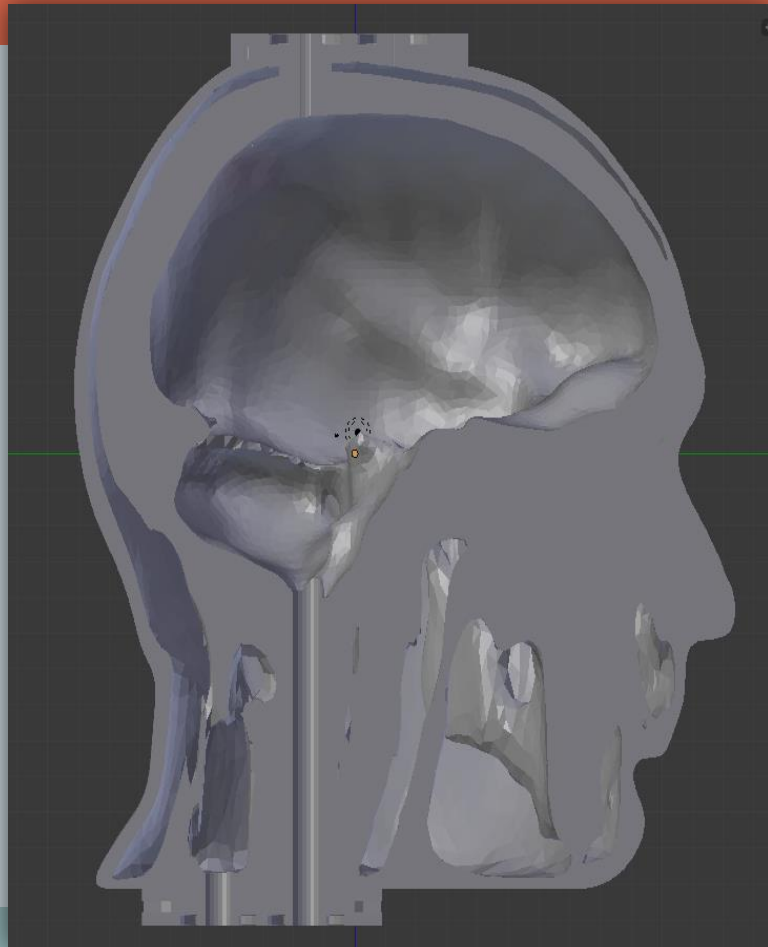
T=25°C f=1.5GHz	ABS	Bone	Skin	CSF	WM	GM	Cerebellum	Muscle	Blood
$\epsilon$	3	11.98	37.58	67.64	37.72	50.74	46.90	54	59.9
$\sigma$ (S/m)	0,01	0.23	1.03	2.72	0.83	1.22	1.55	1,19	1.85



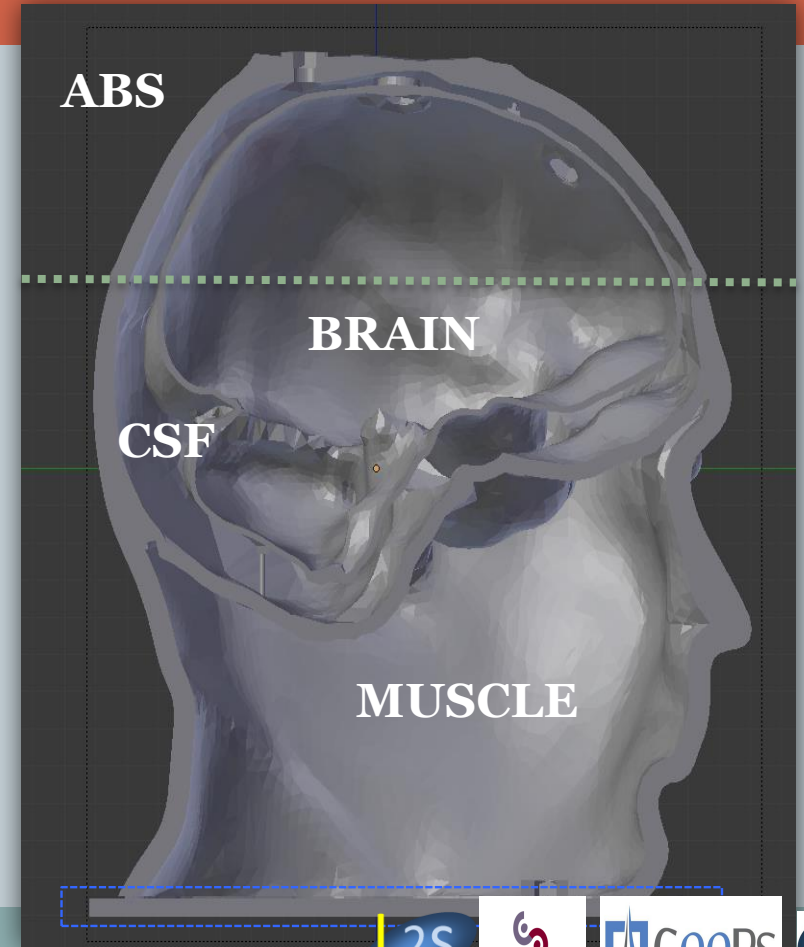
# HEAD PHANTOM

9

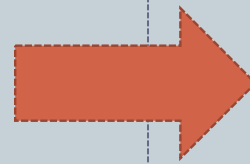
**ORIGINAL FILE**



**MODIFIED FILE**



Cut



Plate

# HEAD PHANTOM GENERATION SUGGESTION:

## Details

10

**Task 1.1** Production, adjustment and measurement of the head tissue mimicking liquid mixtures (EuCAP 2017)

**Task 1.2** Creation of a 3D printed head phantom with cavities, from the STL file downloaded from [http://phantoms.martinos.org/Main\\_Page#Filling](http://phantoms.martinos.org/Main_Page#Filling) , as done for the breast phantom

**Task 2.1** Generation a numerical phantom from the modified STL file

**Task 2.2** Computation of the electromagnetic field inside the phantom with and without infarcted tissue mimicking anomaly; influence of the type of anomaly and of the composition of head for a given configuration (frequency, source, coupling media)

**Task 3.1** Design and realization adapted to the experimental device of the anomaly and of the feed channels that provide access to the various cavities inside the head phantom, including the anomaly **Suggestions ?**

**Task 3.2.** Waterproofing of the different cavities. Production of the physical head phantom

# PROVISIONAL TIMETABLE : our suggestion

MiBraScan Microwave Brain Scanner for Cerebrovascular Diseases Monitoring	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4

as written in the proposal

WP 3	Head phantoms generation		
Task 3.1	Selection of test cases and segmentation		
Task 3.2	Numerical phantoms generation		
Task 3.3	Physical phantoms design and building		

as we suggest it

- Task 3.1 Production, measurement of the head tissue mimicking mixtures  
Design of a 3D anthropomorphic head phantom
- Task 3.2.1 Numerical phantom generation from the STL file
- Task 3.2.2 Simulations from the STL file in the experimental configuration of the device
- Task 3.3.1 Design and realization of the anomaly and of the feed channels adapted to the experimental device–
- Task 3.3.2 Waterproofing the different cavities -Production of a physical head phantom

# MIBRASCAN : a suggestion for the feed channels

