Transmission and absorption analysis at different wavelengths: “ex vivo” study with a supercontinuum white light source

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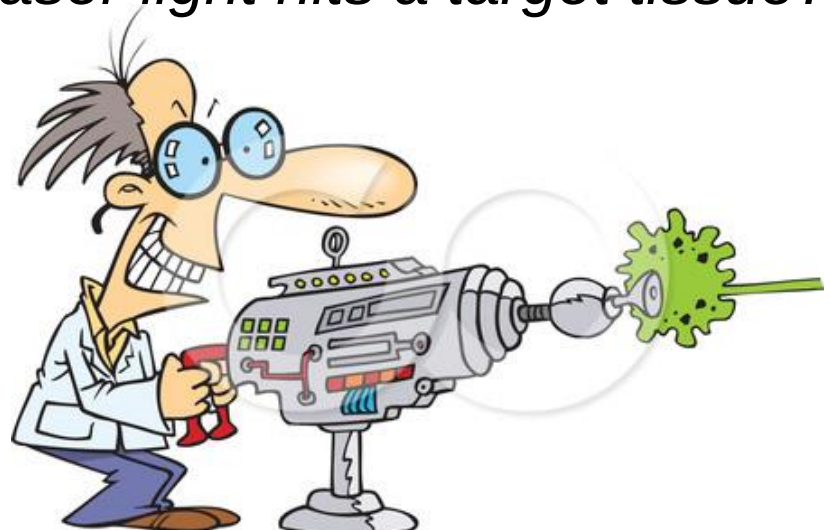
Master Thesis

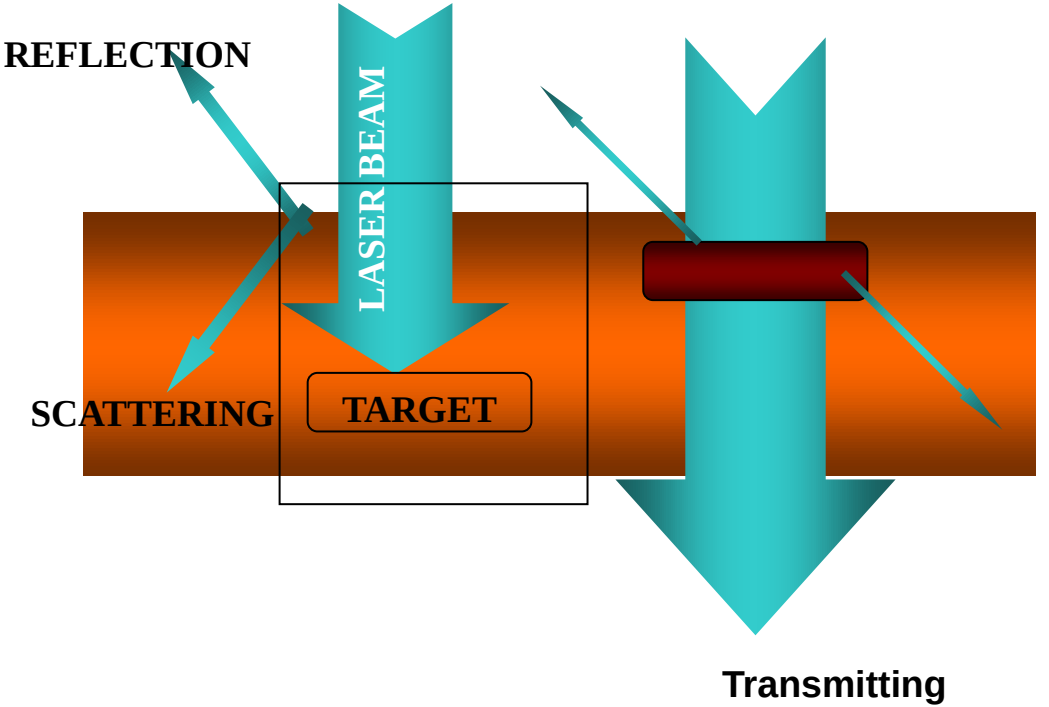
AA YY 2012-2014

EUROPEAN MASTER DEGREE: ORAL LASER APPLICATIONS

EMDOLA

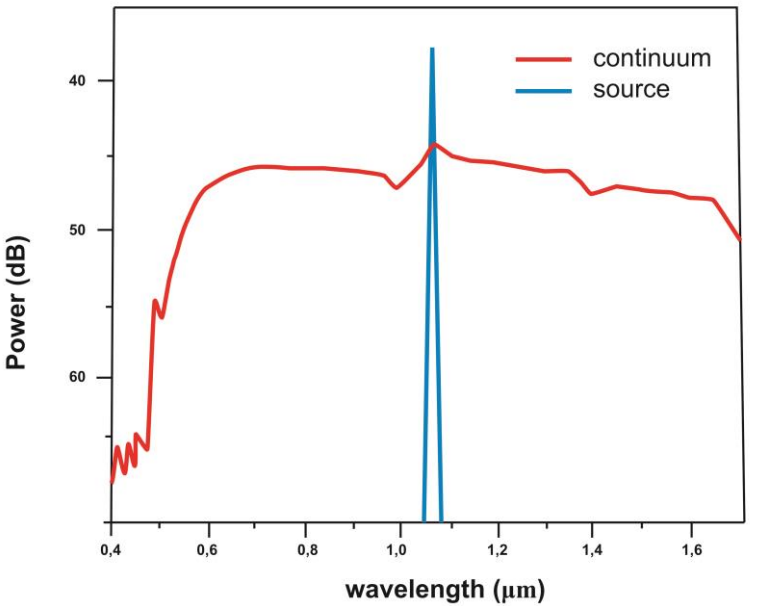
.....What does really happens when the laser light hits a target tissue?.....

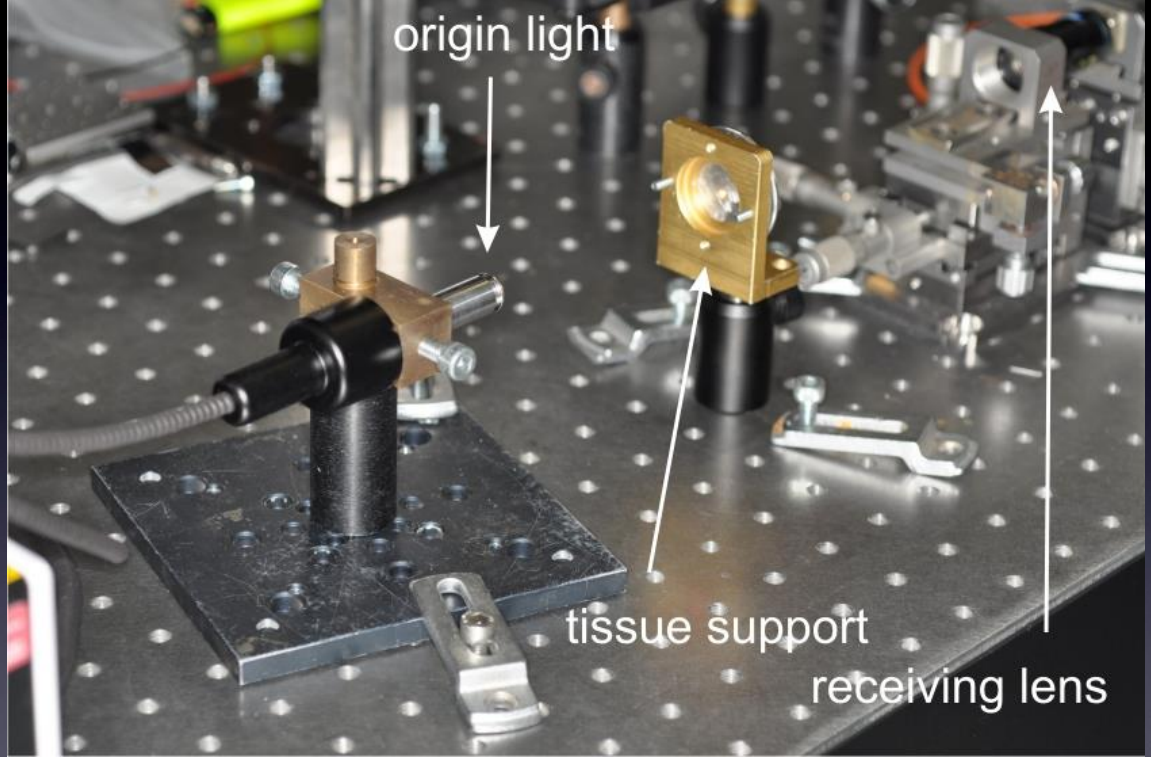


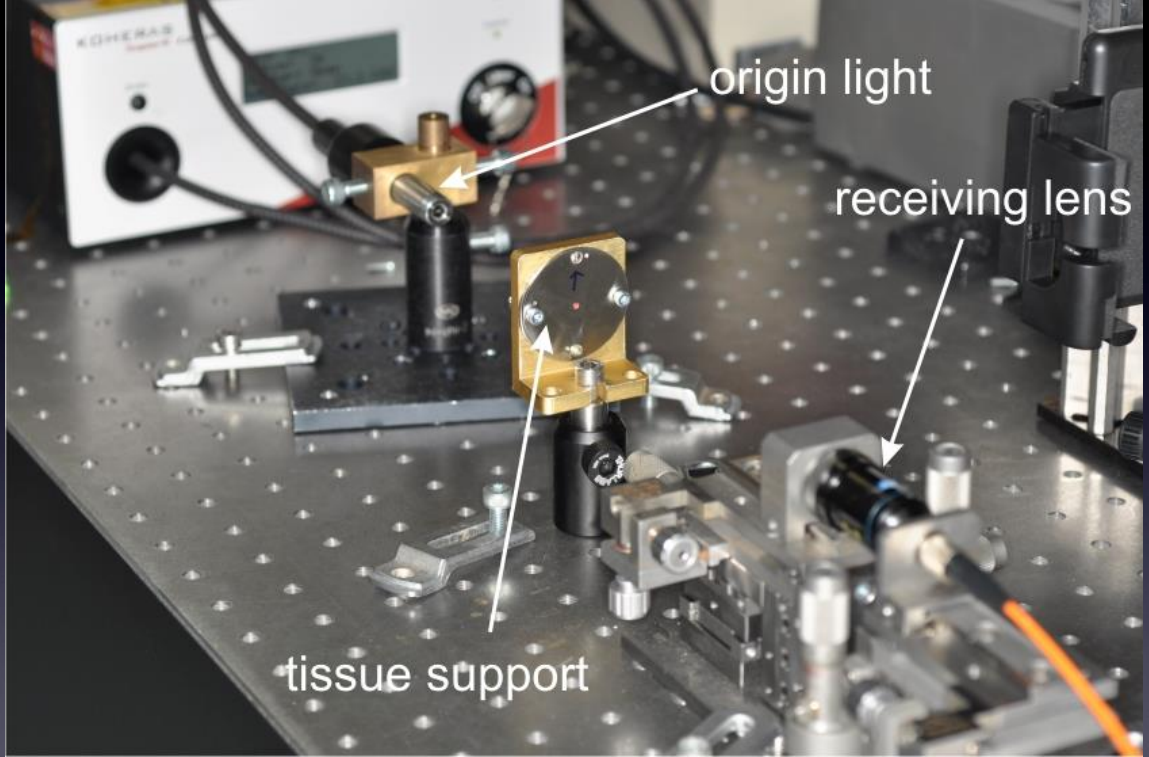

REFLECTION
LASER BEAM
SCATTERING
TARGET
Transmitting

The aim of this study is to determine what are the wavelengths which may be absorbed or transmitted by a specific kind of biological tissue.

light supercontinuum



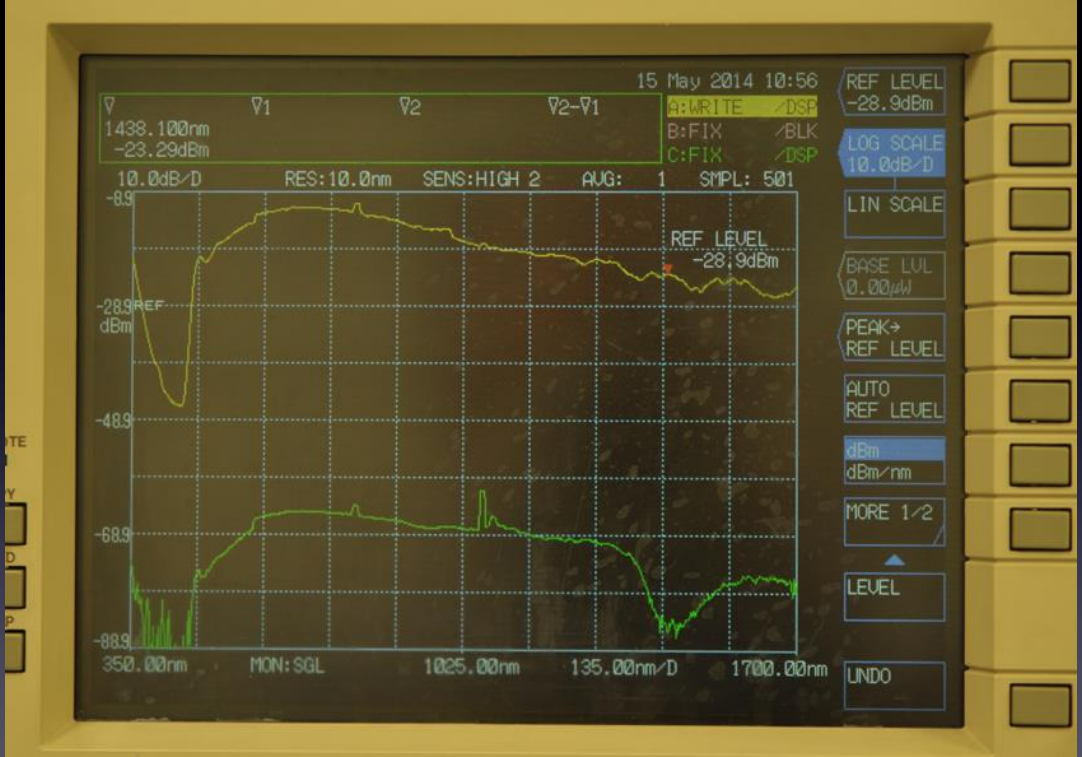

origin light
tissue support
receiving lens


origin light
receiving lens
tissue support

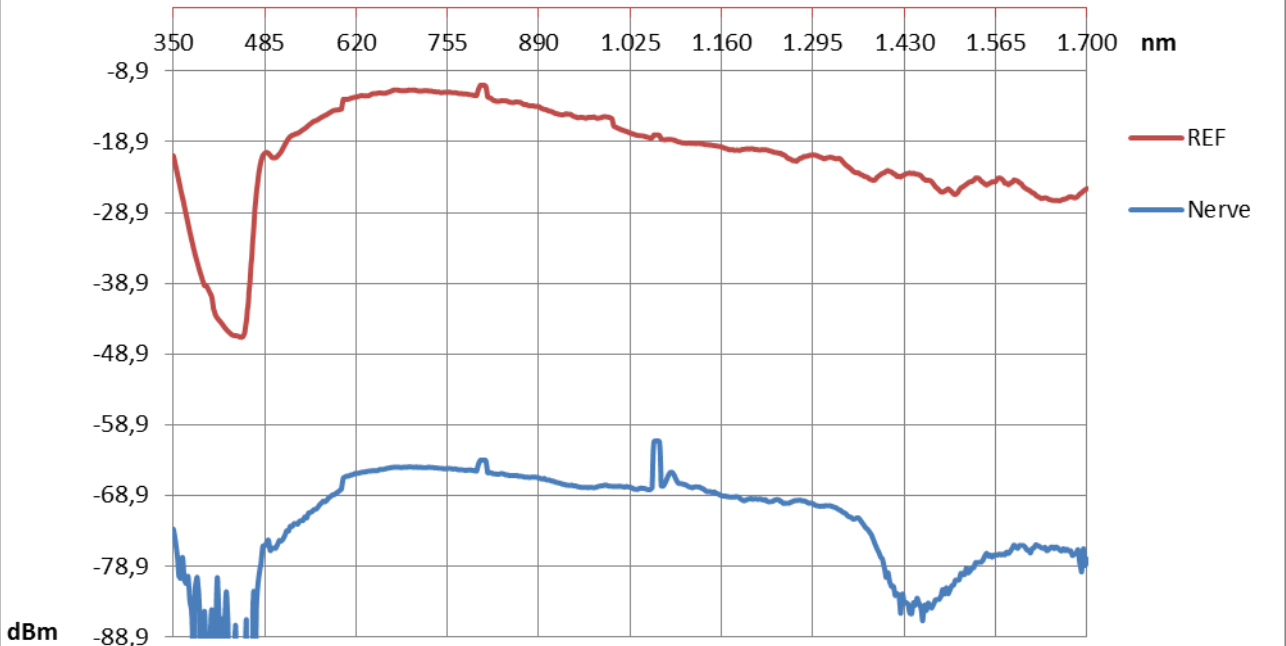

MATUI
0 4 8 1/128in
0 1 2 3 4 5
0 2 4 6 8 10 1/20mm

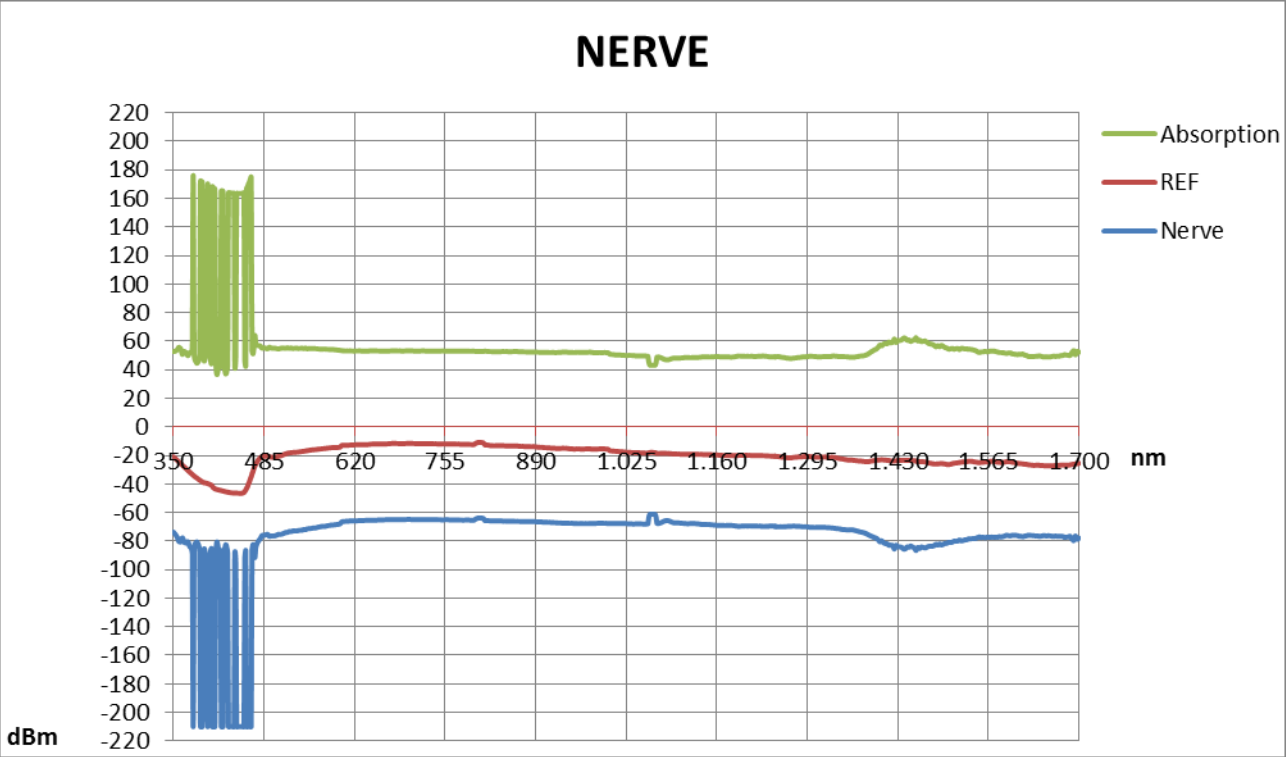
	Tissue	Thickness
1	Nerve	0,2 mm.
2	Skin	0,3 mm.
3	Small Intestine	0,1 mm.
4	Lung	0,3 mm.
5	Esophagus	0,4 mm.
6	Stomach	0,8 mm.
7	Kidney	2,4 mm.
8	Heart	2,2 mm.
9	Spleen	1,2 mm.
10	Liver 1	5,7 mm.
11	Liver 2	2,3 mm.
12	Liver 3	0,6 mm.
13	Muscle 1	2,5 mm.
14	Muscle 2	0,3 mm.
15	Bone	2,2 mm.

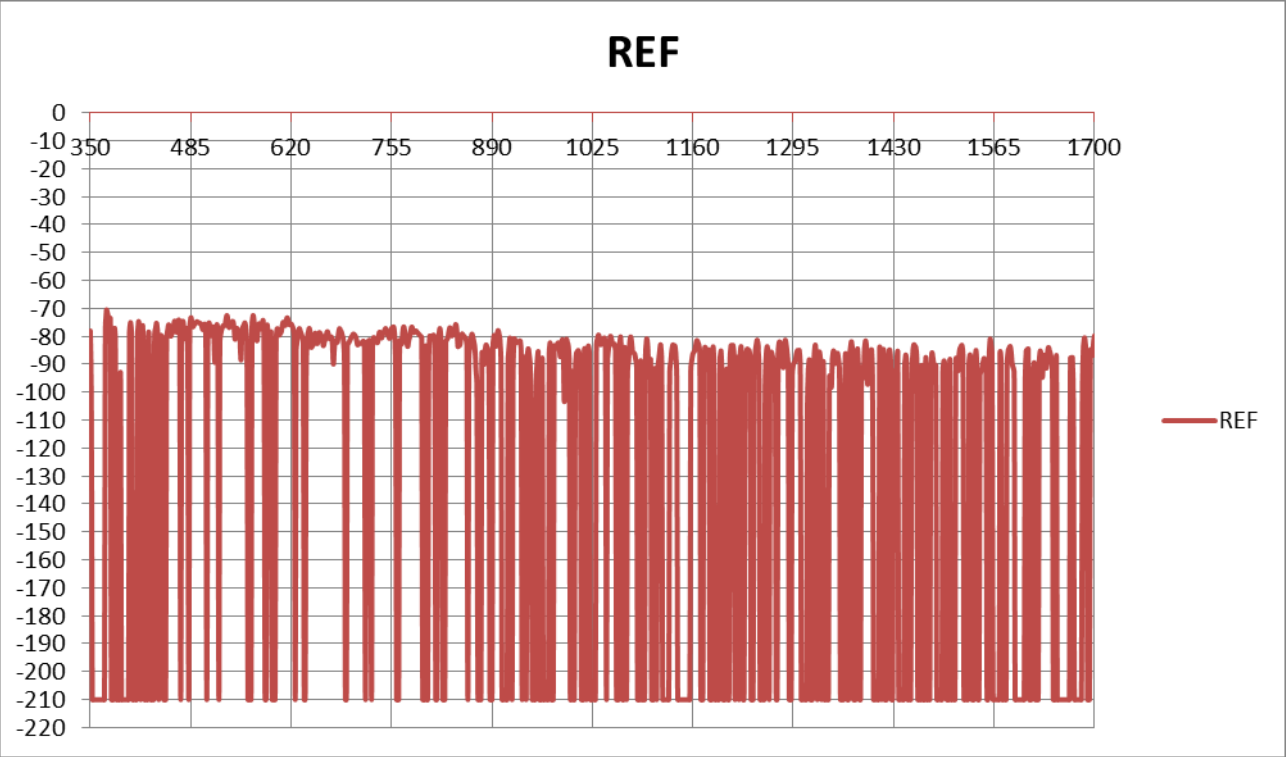
	Tissue	Thickness
1	Small Intestine	0,1 mm.
2	Nerve	0,2 mm.
3	Skin	0,3 mm.
4	Lung	0,3 mm.
5	Muscle 2	0,3 mm.
6	Esophagus	0,4 mm.
7	Liver 3	0,6 mm.
8	Stomach	0,8 mm.
9	Spleen	1,2 mm.
10	Heart	2,2 mm.
11	Bone	2,2 mm.
12	Liver 2	2,3 mm.
13	Kidney	2,4 mm.
14	Muscle 1	2,5 mm.
15	Liver 1	5,7 mm.


15 May 2014 10:56
∇
∇1
∇2
∇2-∇1
1438.100nm
-23.29dBm
A:WRITE /DSP
B:FIX /BLK
C:FIX /DSP
10.0dB/D
RES:10.0nm
SENS:HIGH 2
AVG: 1
SMPL: 501
REF LEVEL
-28.9dBm
-8.9
-28.9 REF dBm
-48.9
-68.9
-88.9
350.00nm
MON:SGL
1025.00nm
135.00nm/D
1700.00nm
REF LEVEL -28.9dBm
LOG SCALE 10.0dB/D
LIN SCALE
BASE LVL 0.00μW
PEAK→ REF LEVEL
AUTO REF LEVEL
dBm
dBm/nm
MORE 1/2
LEVEL
UNDO

NERVE


350
485
620
755
890
1.025
1.160
1.295
1.430
1.565
1.700
nm
-8,9
-18,9
-28,9
-38,9
-48,9
-58,9
-68,9
-78,9
-88,9
dBm
REF
Nerve


NERVE
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
dBm
350
485
620
755
890
1.025
1.160
1.295
1.430
1.565
1.700
nm
Absorption
REF
Nerve


REF
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
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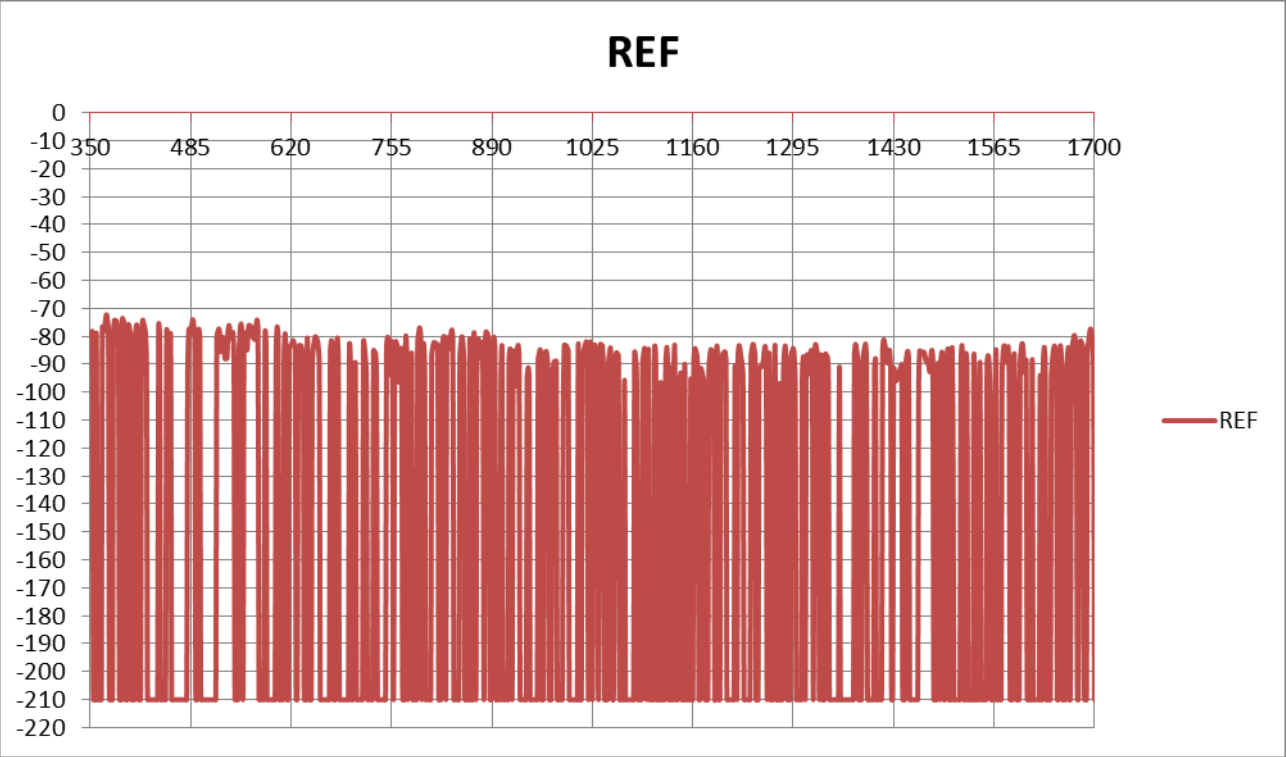
-150
-160
-170
-180
-190
-200
-210
-220
350
485
620
755
890
1025
1160
1295
1430
1565
1700
REF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-80
-90
-100
-110
-120
-130
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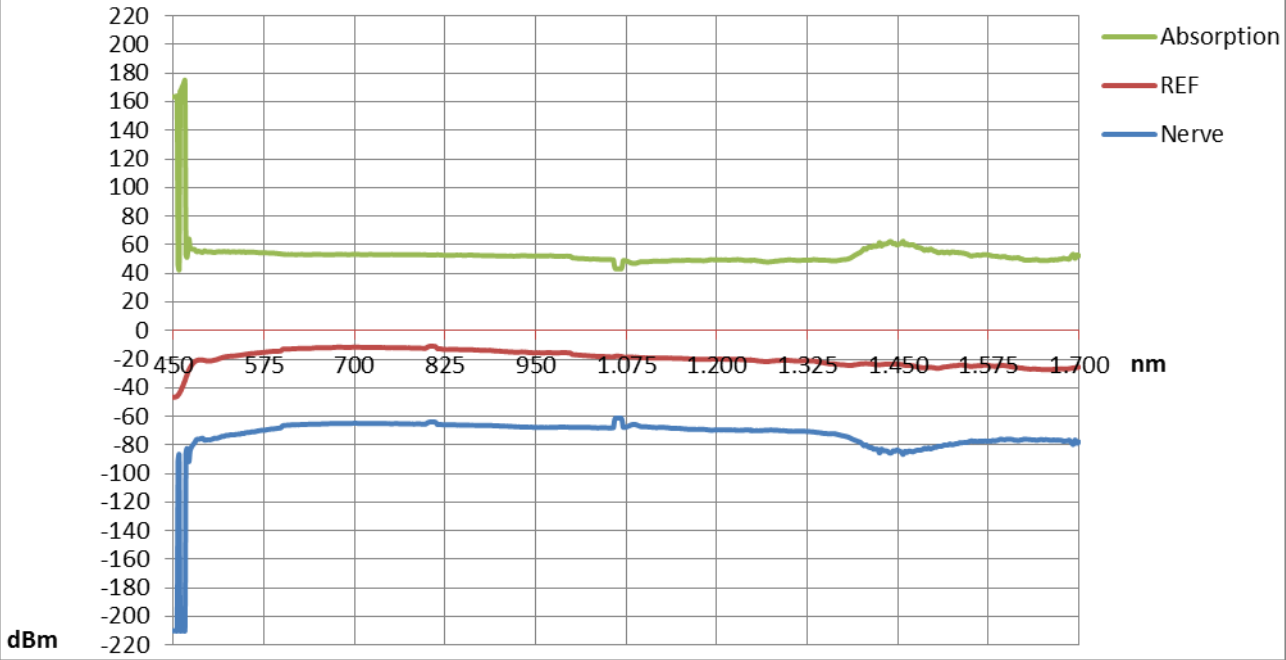
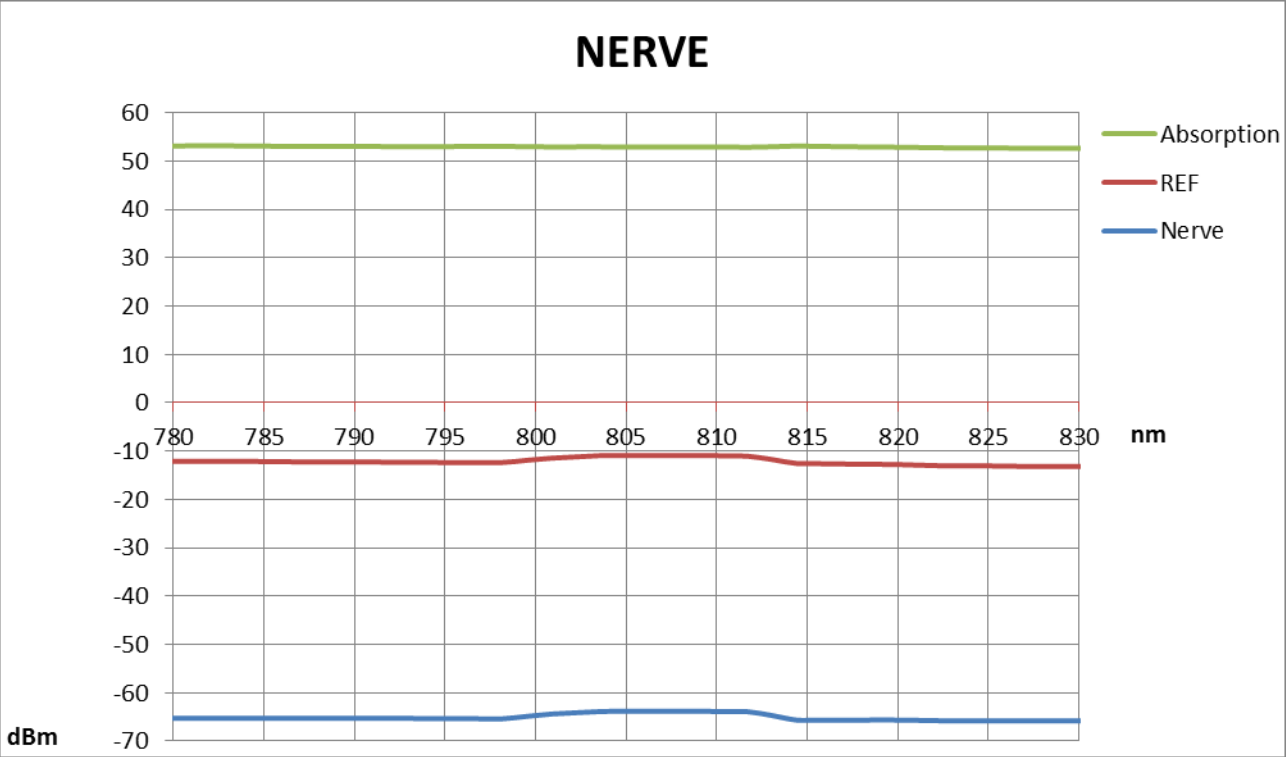
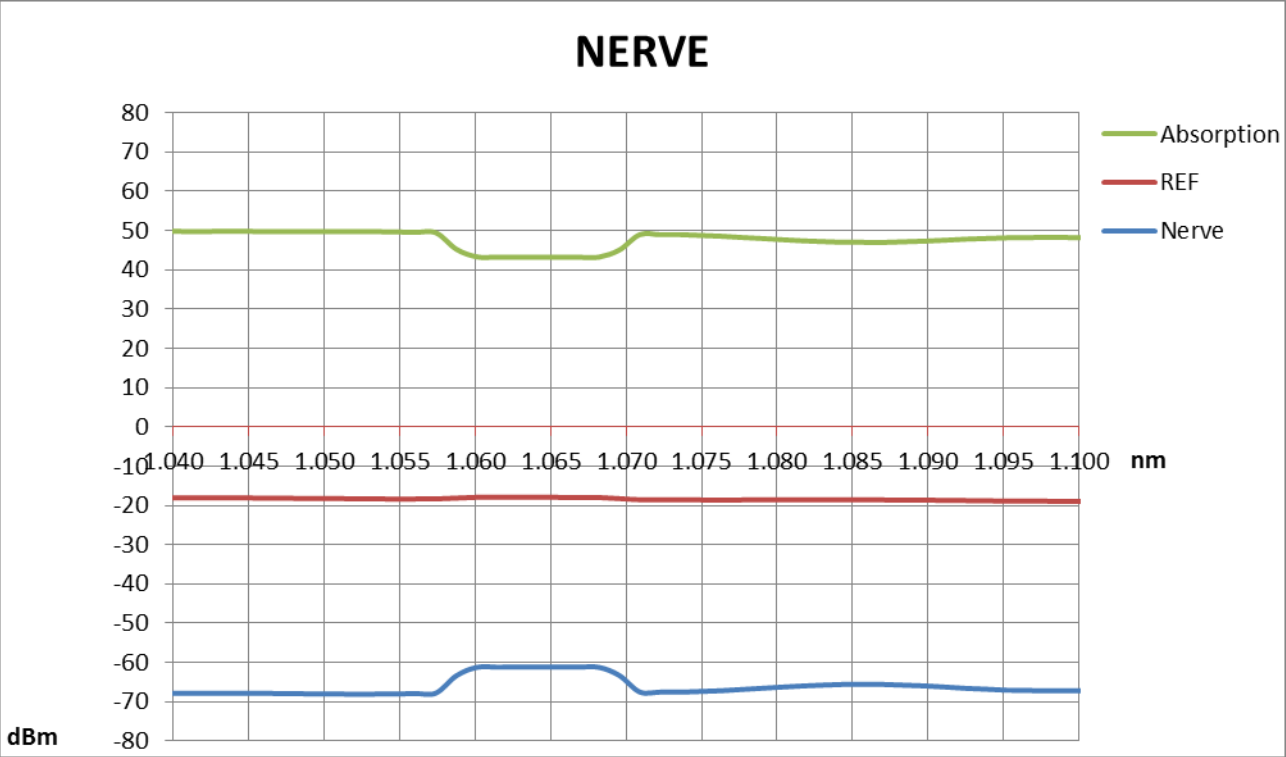
-160
-170
-180
-190
-200
-210
-220
350
485
620
755
890
1025
1160
1295
1430
1565
1700
REF

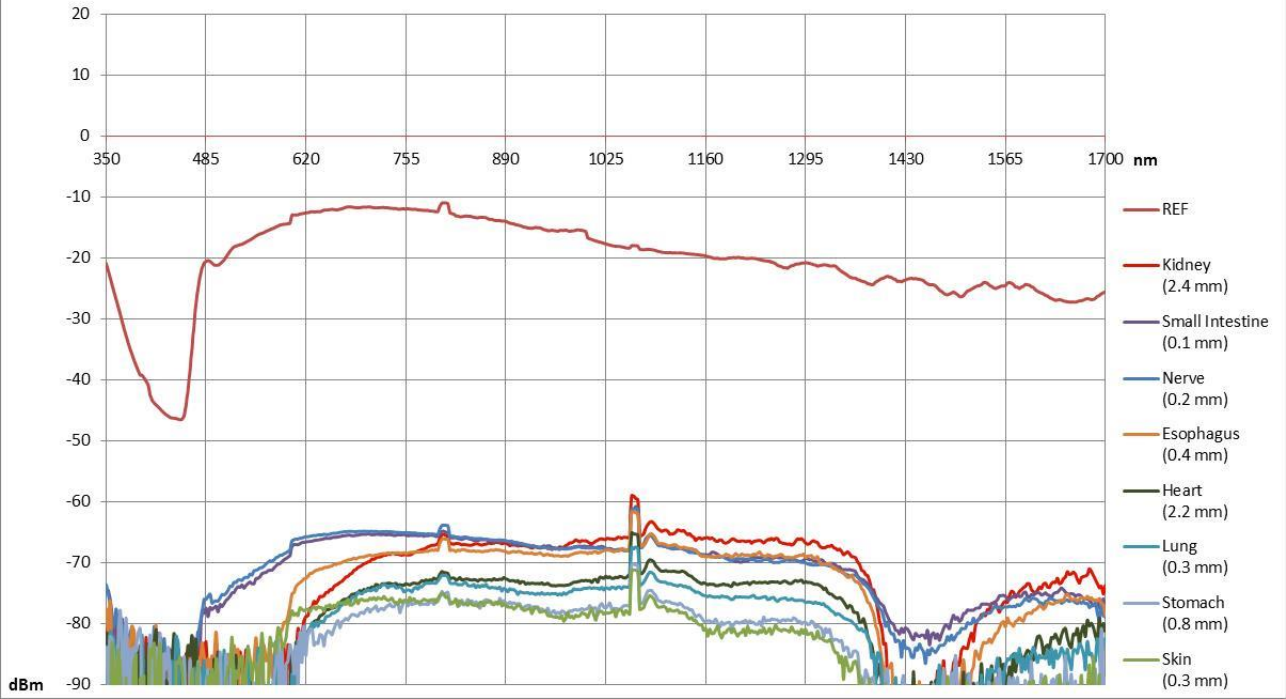
NERVE

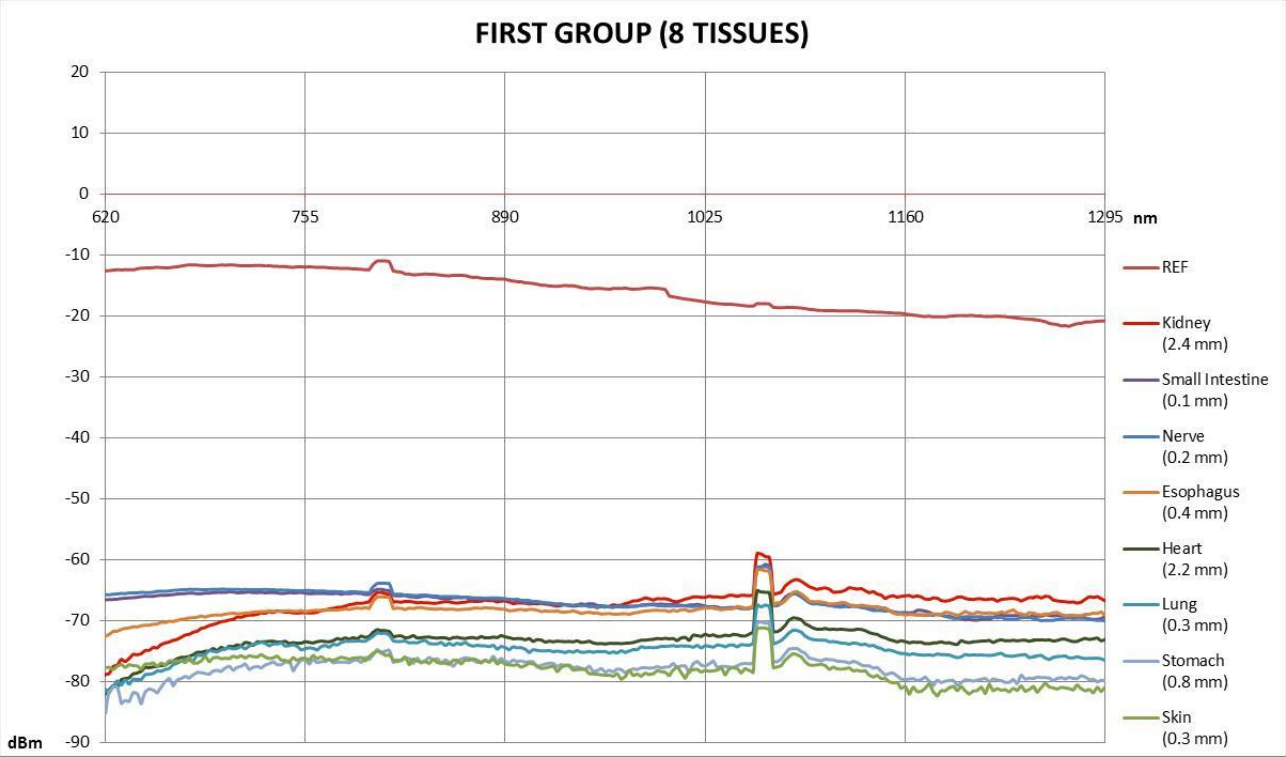

220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
dBm
450
575
700
825
950
1.075
1.200
1.325
1.450
1.575
1.700
nm
Absorption
REF
Nerve

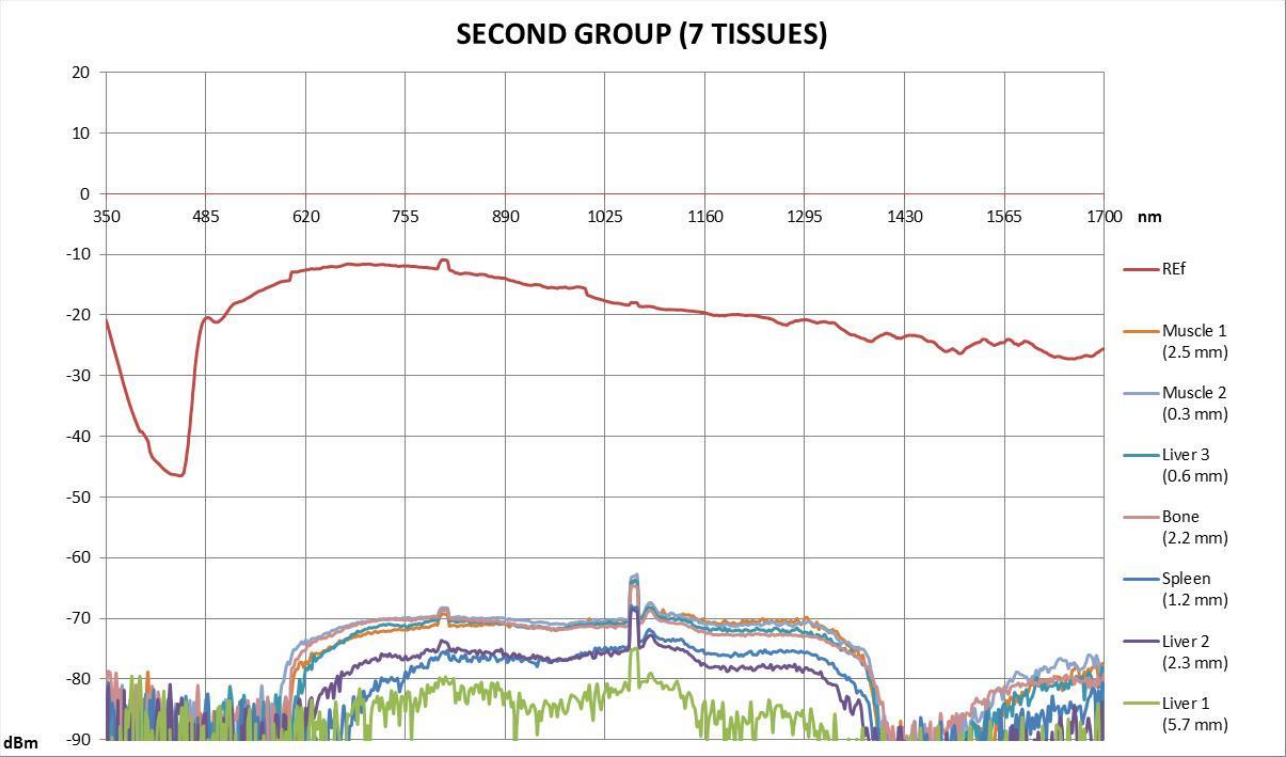

NERVE
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
dBm
780
785
790
795
800
805
810
815
820
825
830
nm
Absorption
REF
Nerve

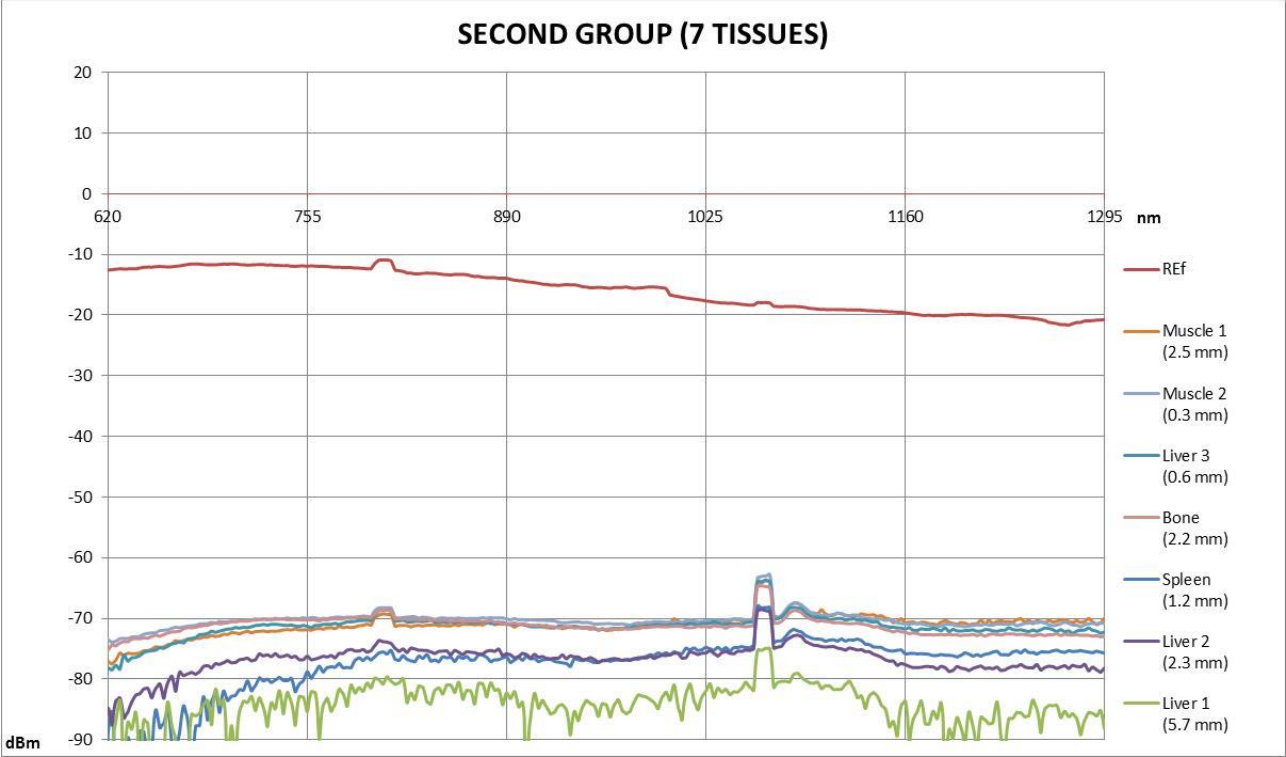

NERVE
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
dBm
1.040 1.045 1.050 1.055 1.060 1.065 1.070 1.075 1.080 1.085 1.090 1.095 1.100
nm
Absorption
REF
Nerve

FIRST GROUP (8 TISSUES)

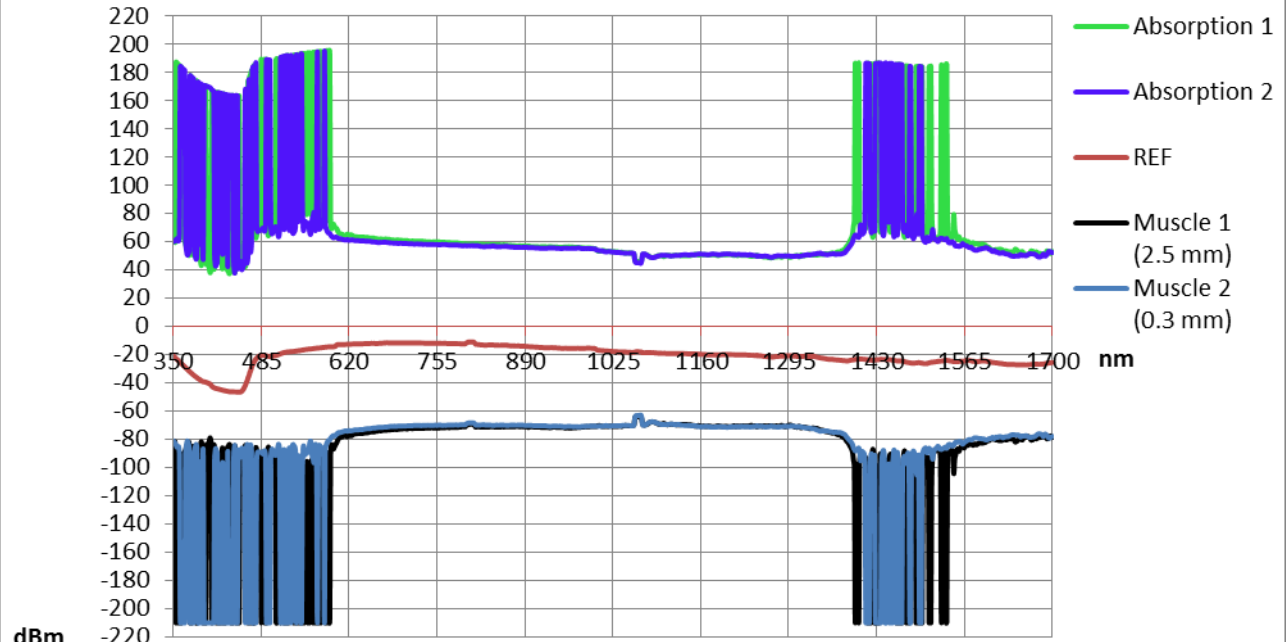


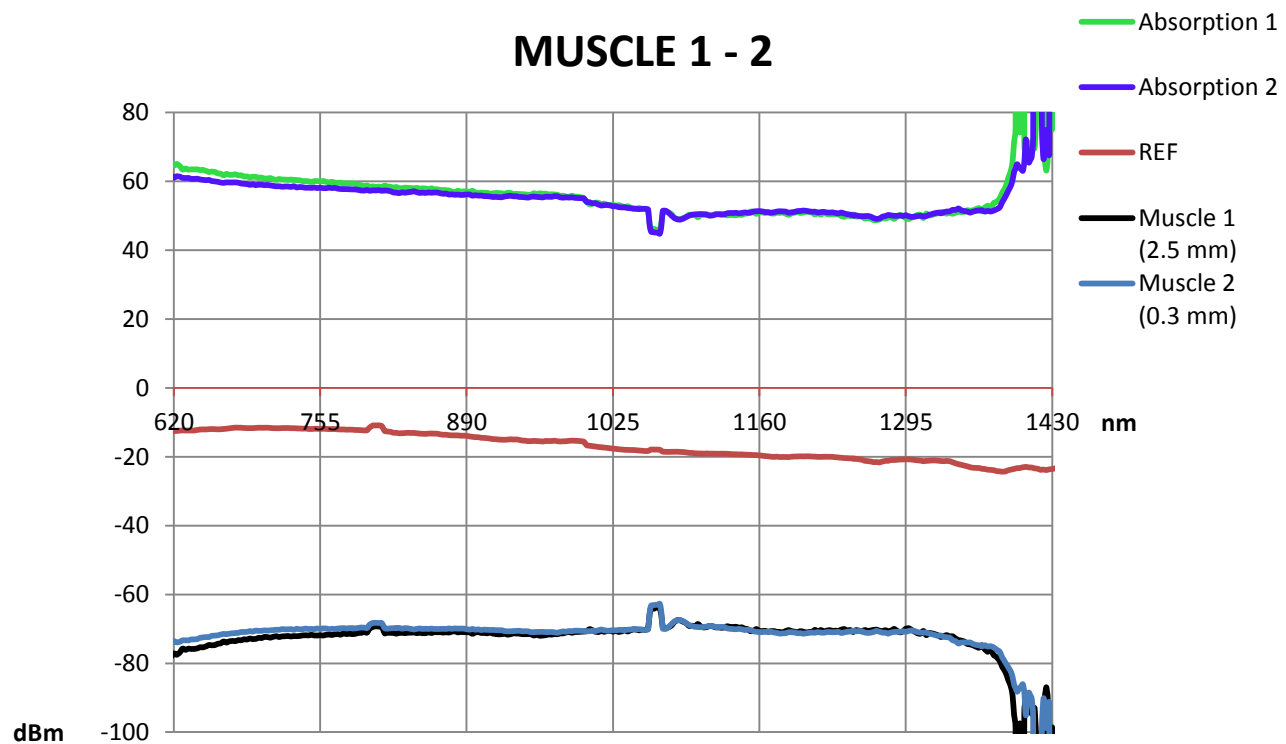

FIRST GROUP (8 TISSUES)
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
dBm
620
755
890
1025
1160
1295
nm
REF
Kidney (2.4 mm)
Small Intestine (0.1 mm)
Nerve (0.2 mm)
Esophagus (0.4 mm)
Heart (2.2 mm)
Lung (0.3 mm)
Stomach (0.8 mm)
Skin (0.3 mm)


SECOND GROUP (7 TISSUES)
20
10
0
350
485
620
755
890
1025
1160
1295
1430
1565
1700
nm
-10
-20
-30
-40
-50
-60
-70
-80
-90
dBm
REf
Muscle 1 (2.5 mm)
Muscle 2 (0.3 mm)
Liver 3 (0.6 mm)
Bone (2.2 mm)
Spleen (1.2 mm)
Liver 2 (2.3 mm)
Liver 1 (5.7 mm)

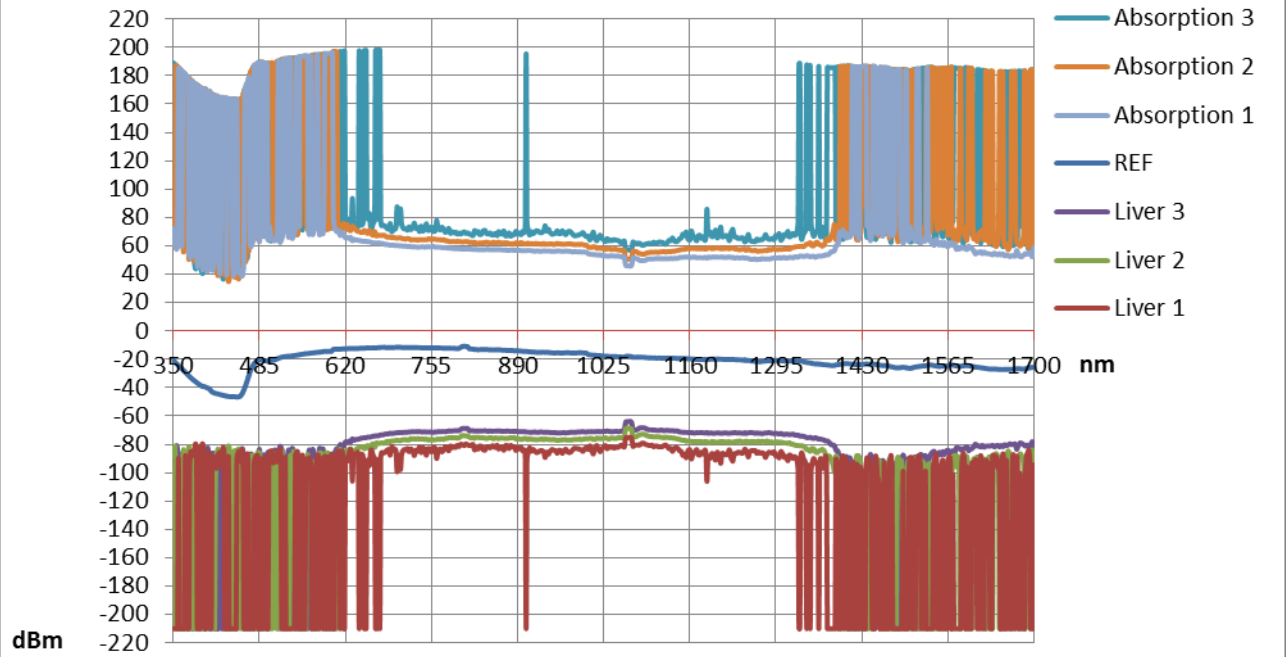

SECOND GROUP (7 TISSUES)
20
10
0
620
755
890
1025
1160
1295
nm
-10
-20
-30
-40
-50
-60
-70
-80
-90
dBm
REf
Muscle 1 (2.5 mm)
Muscle 2 (0.3 mm)
Liver 3 (0.6 mm)
Bone (2.2 mm)
Spleen (1.2 mm)
Liver 2 (2.3 mm)
Liver 1 (5.7 mm)

MUSCLE 1 - 2

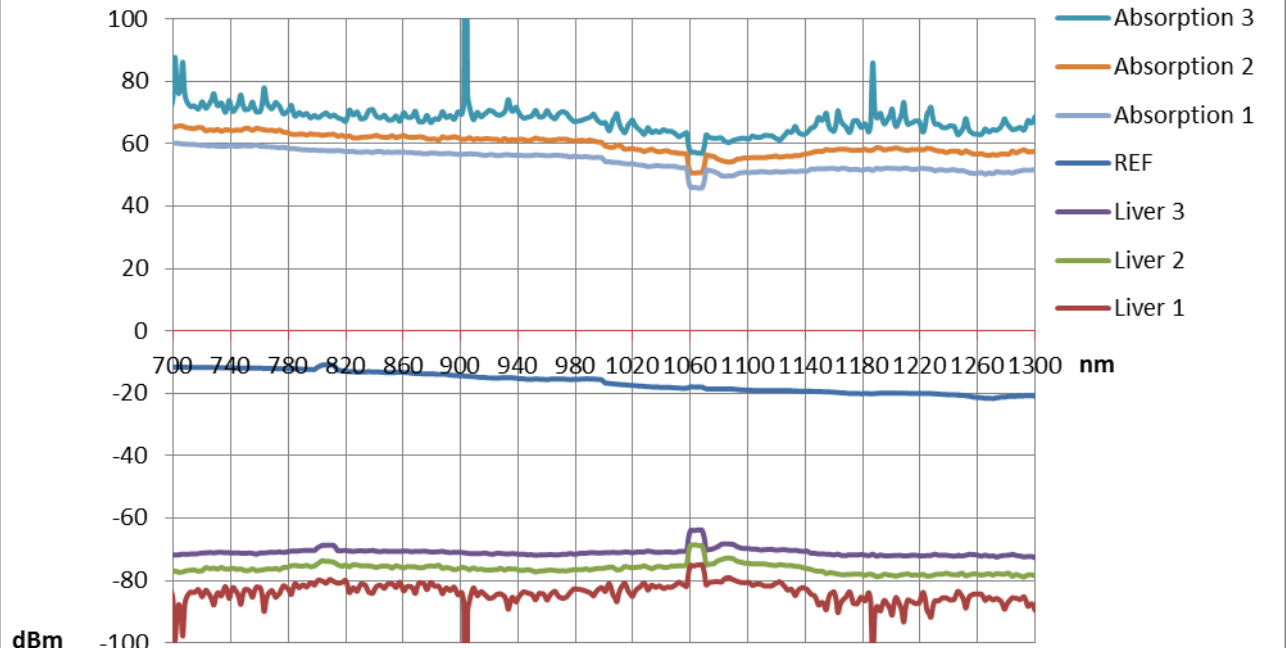

220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
dBm
350
485
620
755
890
1025
1160
1295
1430
1565
1700
nm
Absorption 1
Absorption 2
REF
Muscle 1 (2.5 mm)
Muscle 2 (0.3 mm)

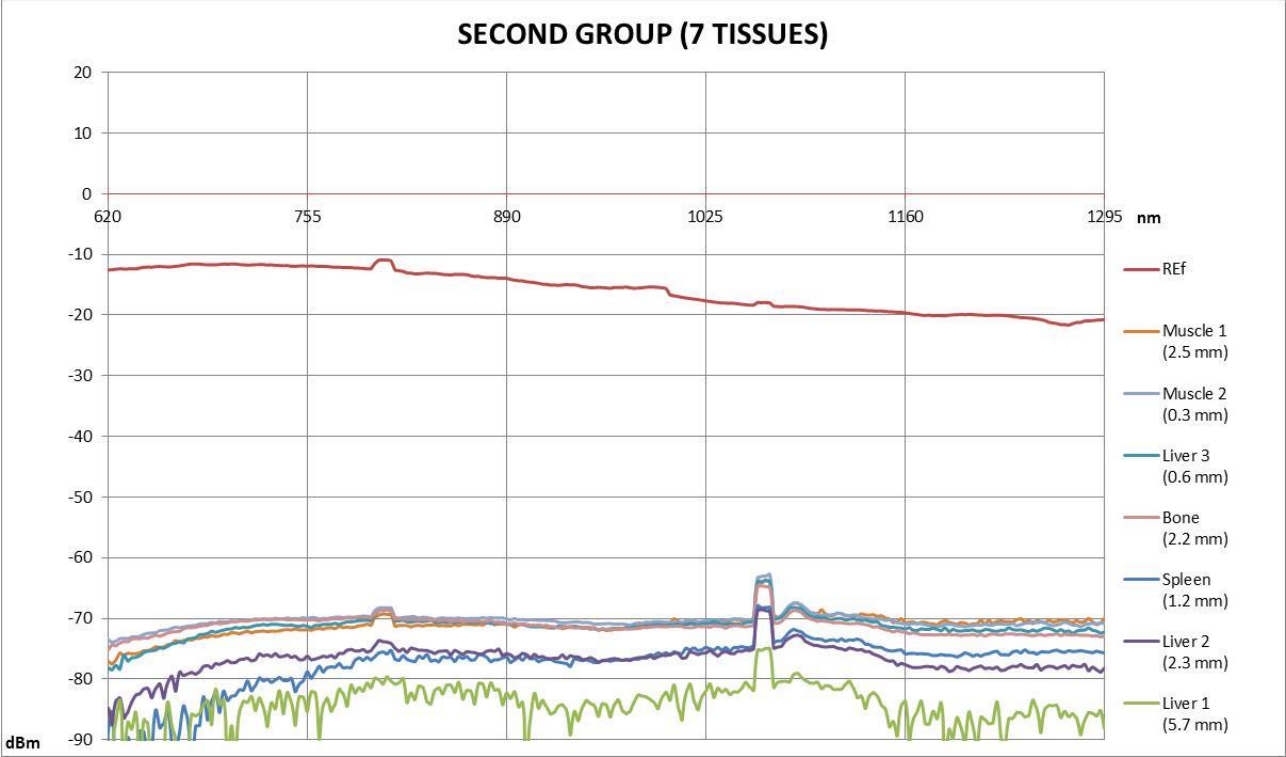

MUSCLE 1 - 2
Absorption 1
Absorption 2
REF
Muscle 1 (2.5 mm)
Muscle 2 (0.3 mm)
80
60
40
20
0
-20
-40
-60
-80
-100
dBm
620
755
890
1025
1160
1295
1430
nm

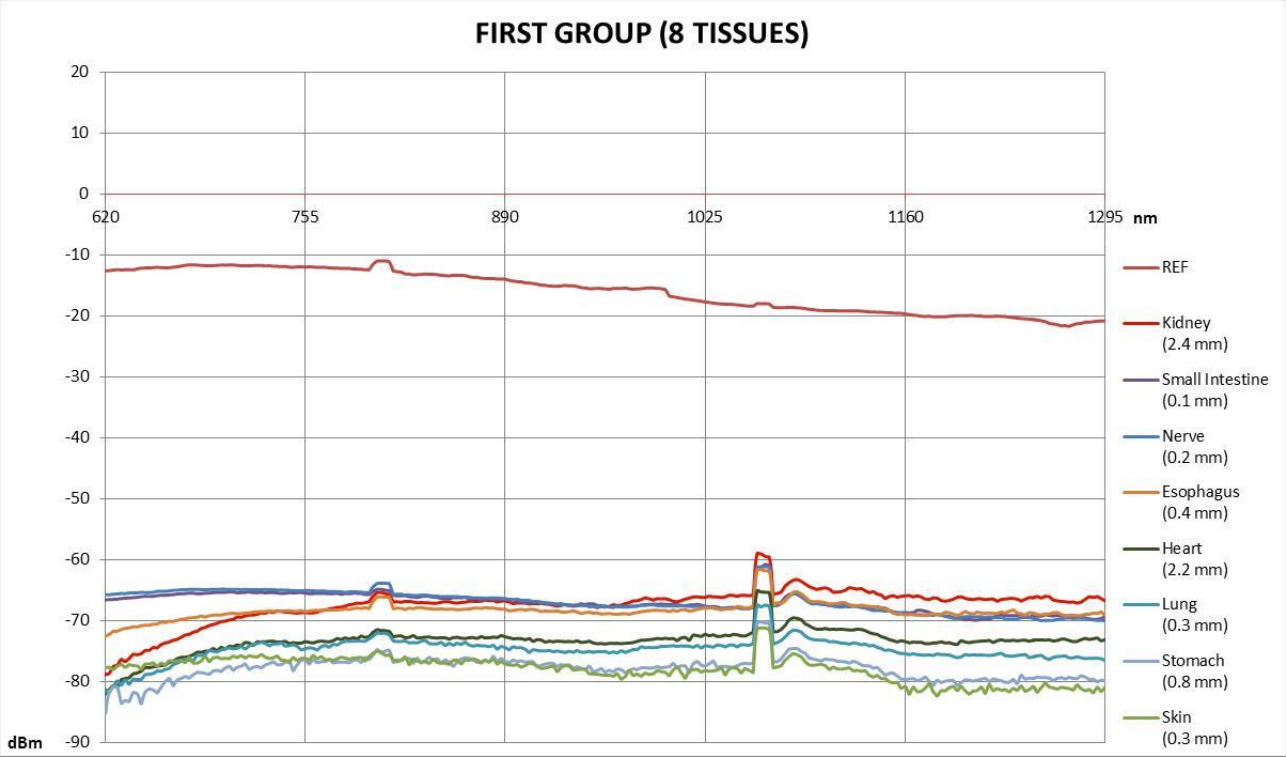
LIVER 1 - 2 - 3


220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
dBm
350
485
620
755
890
1025
1160
1295
1430
1565
1700
nm
Absorption 3
Absorption 2
Absorption 1
REF
Liver 3
Liver 2
Liver 1

LIVER 1 - 2 - 3

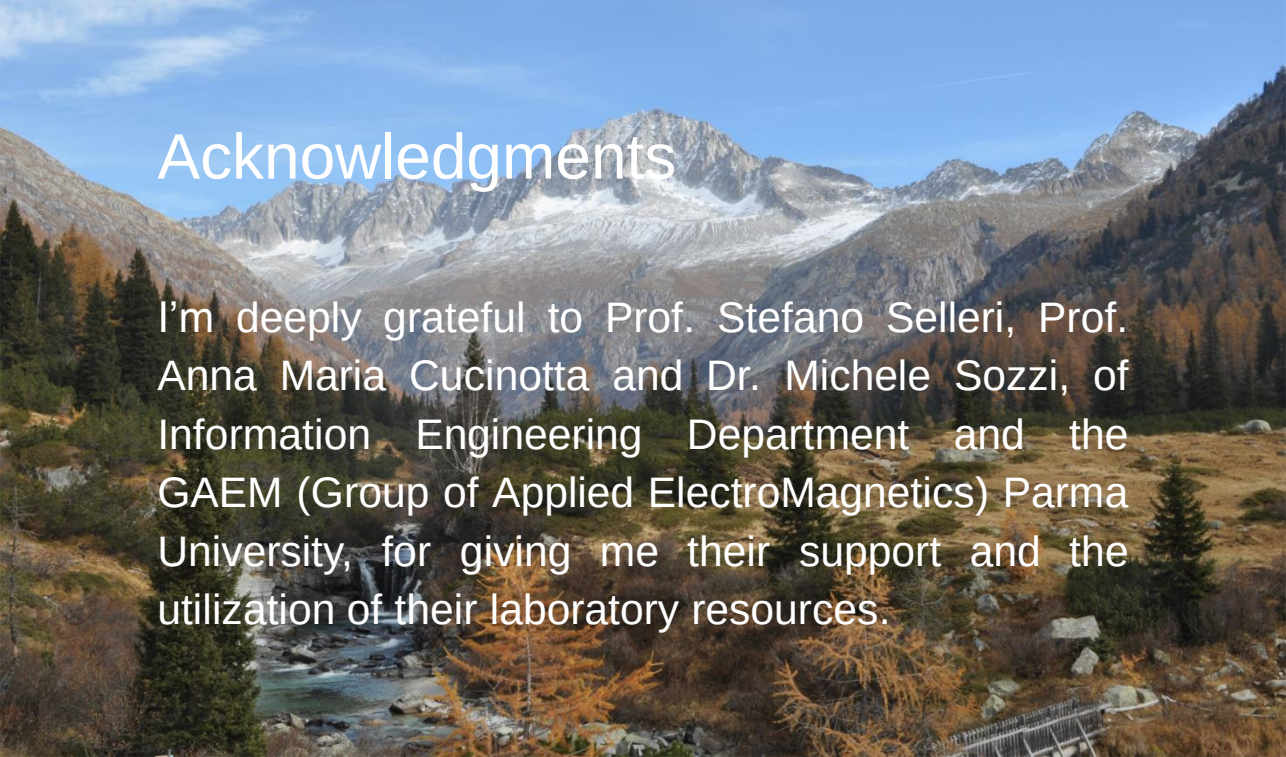

100
80
60
40
20
0
-20
-40
-60
-80
-100
dBm
700 740 780 820 860 900 940 980 1020 1060 1100 1140 1180 1220 1260 1300
nm
Absorption 3
Absorption 2
Absorption 1
REF
Liver 3
Liver 2
Liver 1


SECOND GROUP (7 TISSUES)
20
10
0
620
755
890
1025
1160
1295
nm
-10
-20
-30
-40
-50
-60
-70
-80
-90
dBm
REf
Muscle 1 (2.5 mm)
Muscle 2 (0.3 mm)
Liver 3 (0.6 mm)
Bone (2.2 mm)
Spleen (1.2 mm)
Liver 2 (2.3 mm)
Liver 1 (5.7 mm)


FIRST GROUP (8 TISSUES)
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
dBm
620
755
890
1025
1160
1295
nm
REF
Kidney (2.4 mm)
Small Intestine (0.1 mm)
Nerve (0.2 mm)
Esophagus (0.4 mm)
Heart (2.2 mm)
Lung (0.3 mm)
Stomach (0.8 mm)
Skin (0.3 mm)

Conclusions

- the thickness is not decisive to allow light to pass into the tissue
- the thickness is decisive only in the tissues analysis of the same kind and the thickness will condition the passage of light only in the tissues of the same nature
- in tissues different the light passage has an unpredictable behavior



Acknowledgments

I’m deeply grateful to Prof. Stefano Selleri, Prof. Anna Maria Cucinotta and Dr. Michele Sozzi, of Information Engineering Department and the GAEM (Group of Applied ElectroMagnetics) Parma University, for giving me their support and the utilization of their laboratory resources.