



# “Time-lapse” case study of impedance tomography on beech

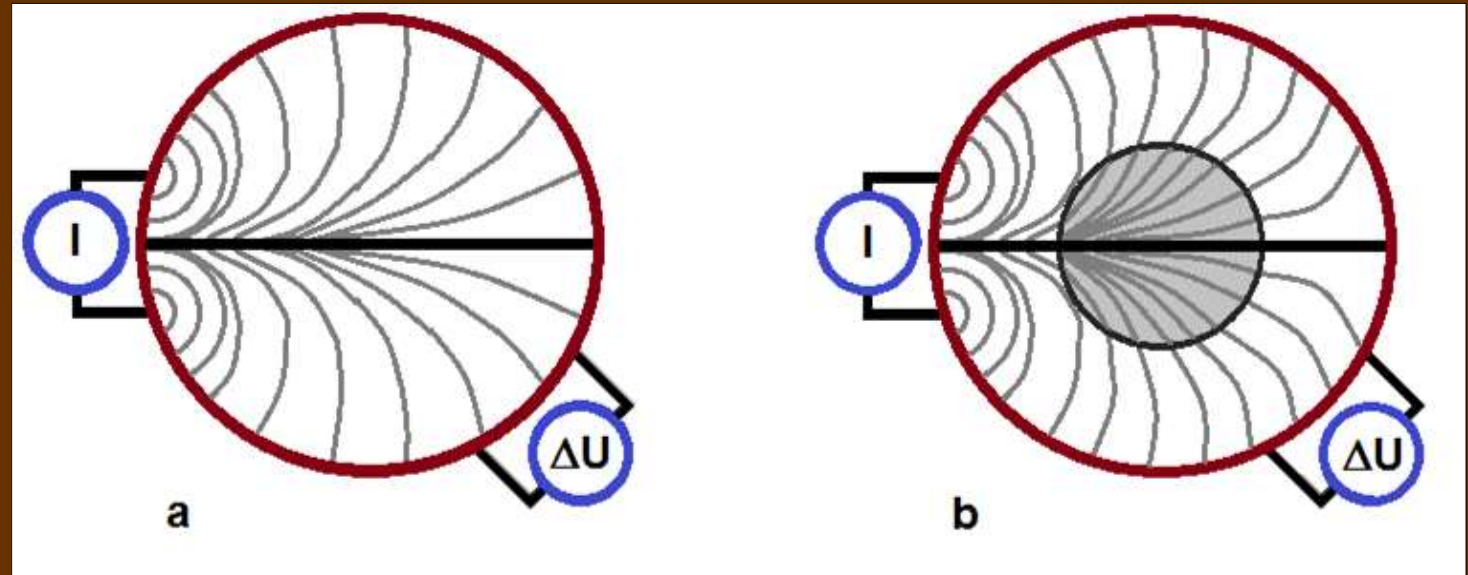
Ágnes Kinga Buza, PhD  
Prof. Ferenc Divós  
Freiburg, 2019. 9. 26.



# Impedance tomography



- ∞ From geophysics
- ∞ Currents and Voltages
- ∞ Sensitive for ion concentrates
- ∞ Inhomogeneity can be found

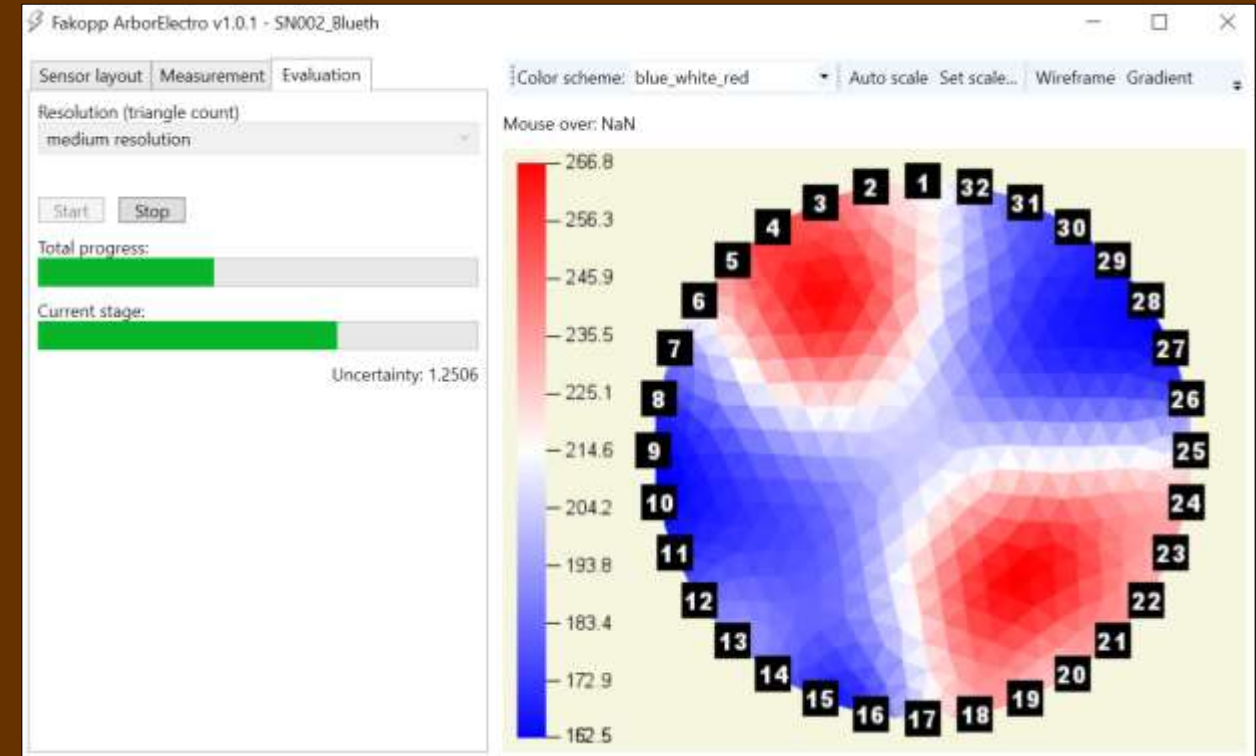
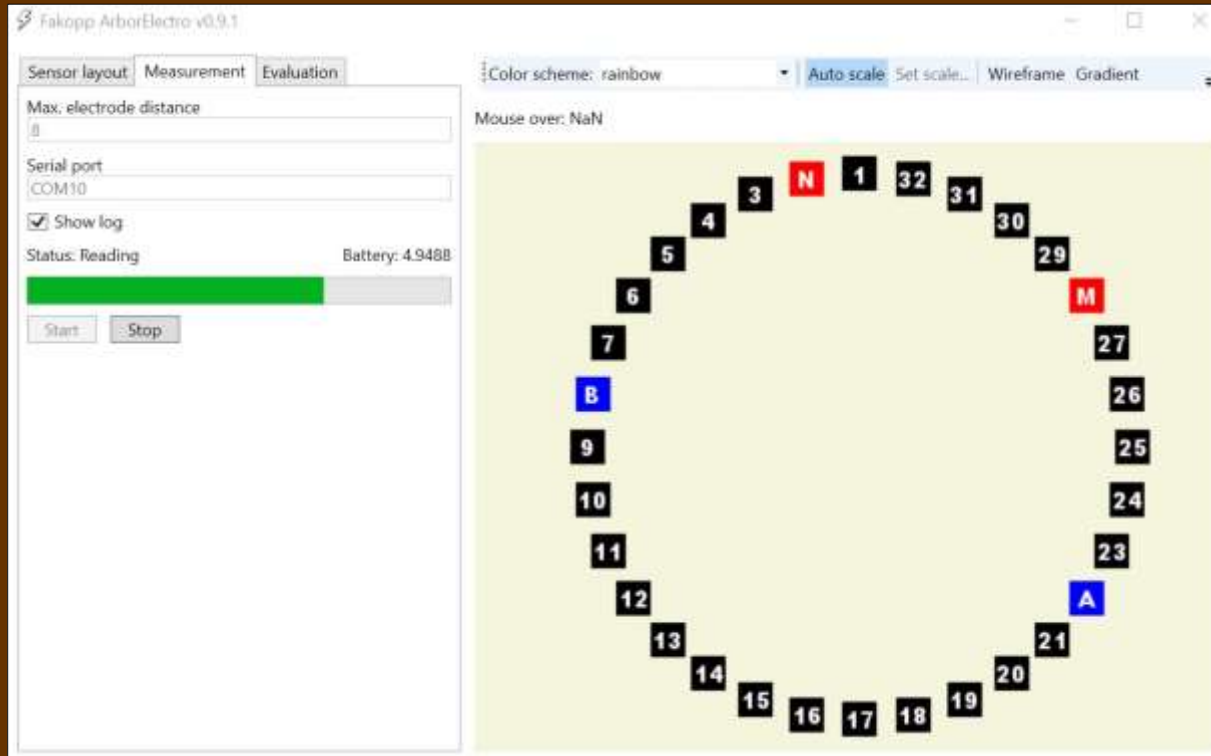


# ArborElectro





# Measurement and evaluation

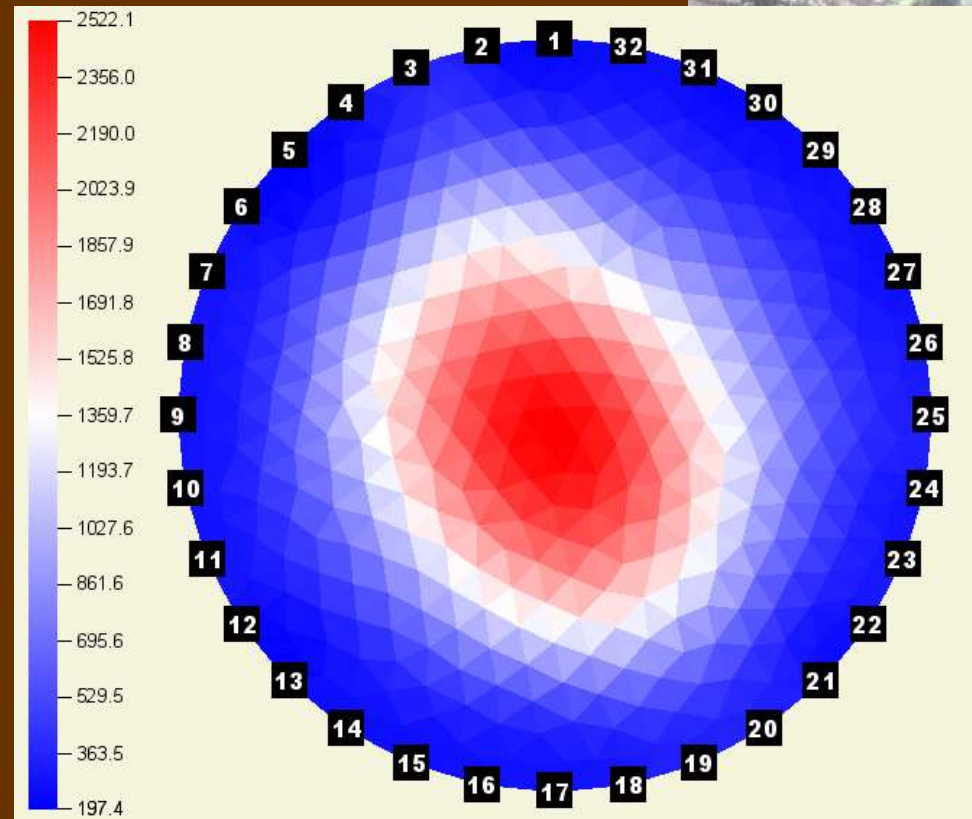


- The software handles both the measurement and the evaluation
- Evaluation is a 5 steps iteration

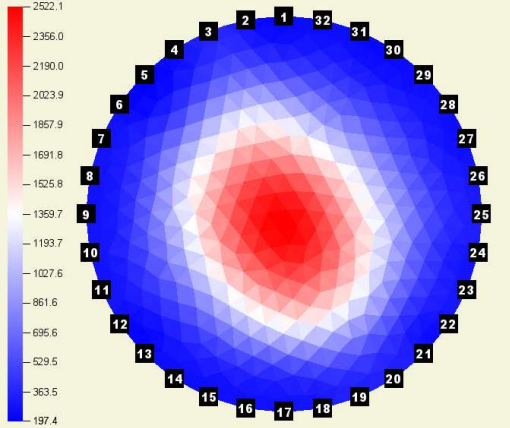
# Healthy spruce



- ∞ The pattern can be different for the different species
- ∞ First a healthy tomogram should be measured
- ∞ Healthy and infected tomograms can be compared



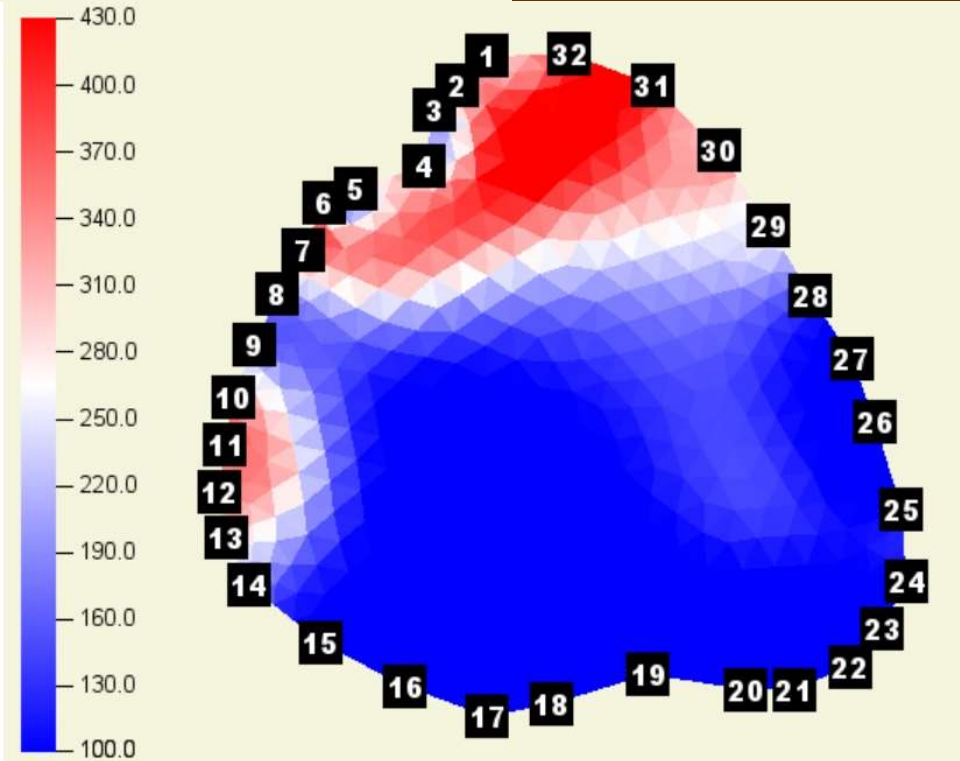




Healthy spruce

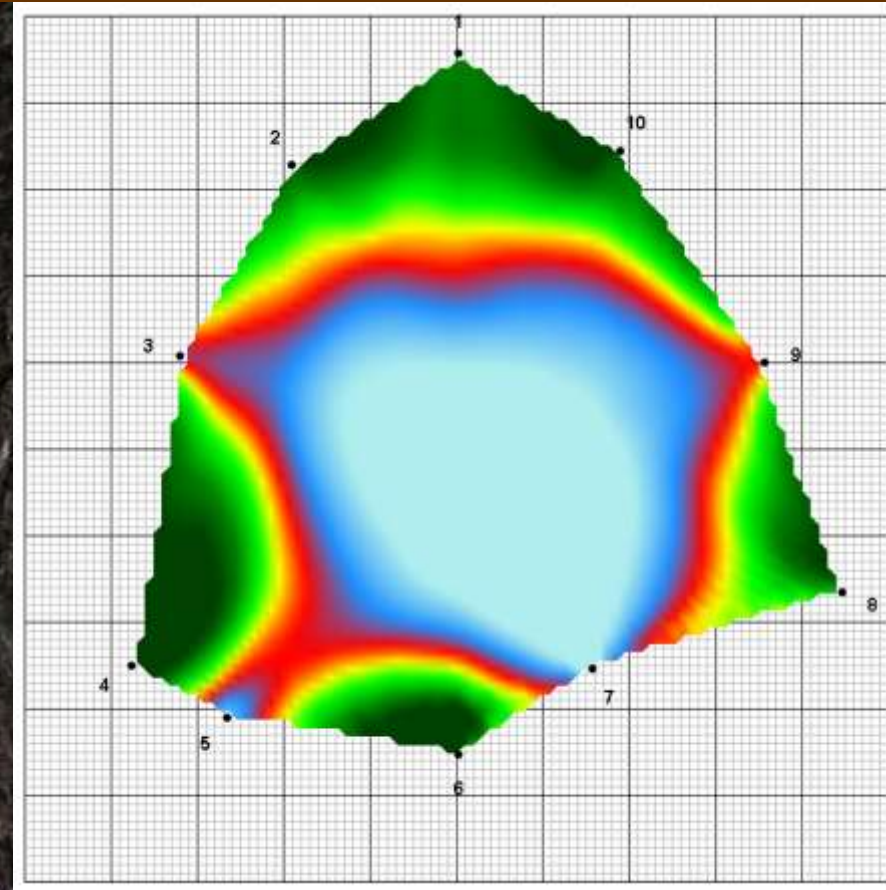
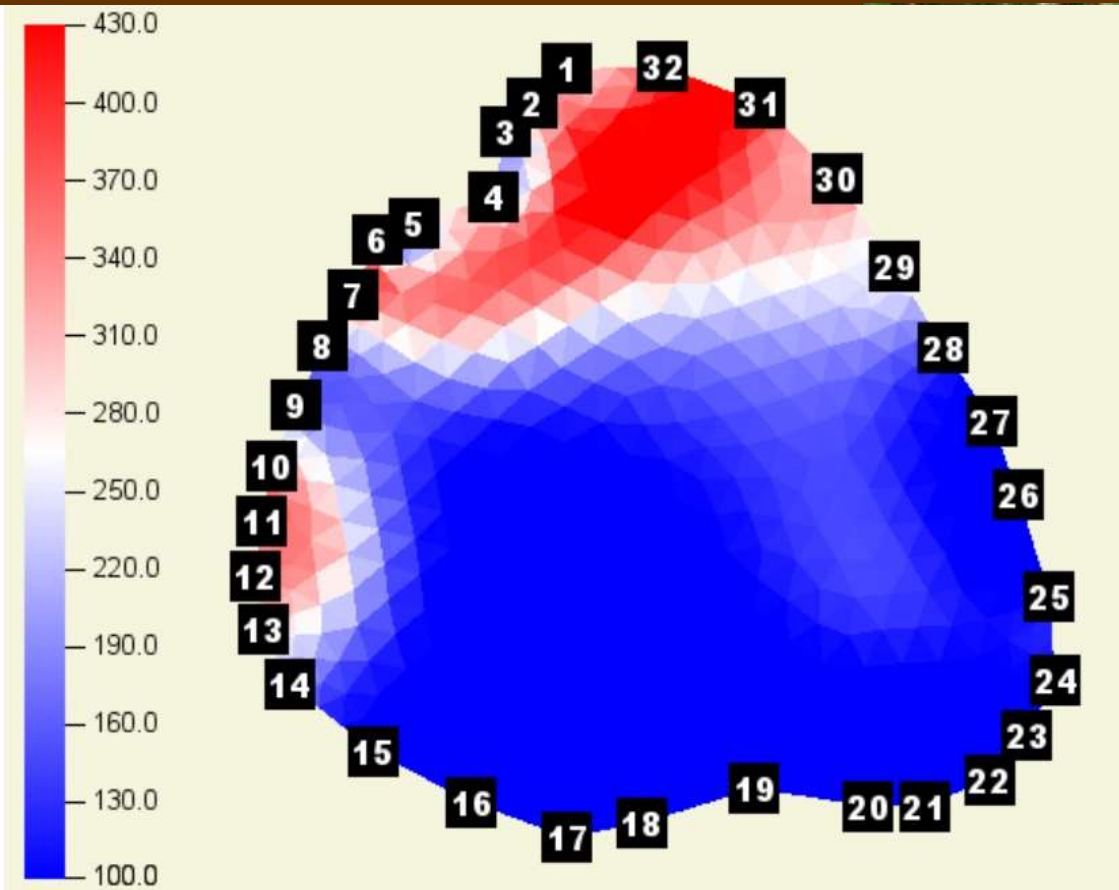


Attacked  
spruce



∞ Resistivity decreases, conductivity increases  
if a fungi is actively infecting the tree

# Attacked spruce – comparison with acoustic tomography



Even if there is wood material inside, it's load bearing capacity is very low



# Attacked ash – another example

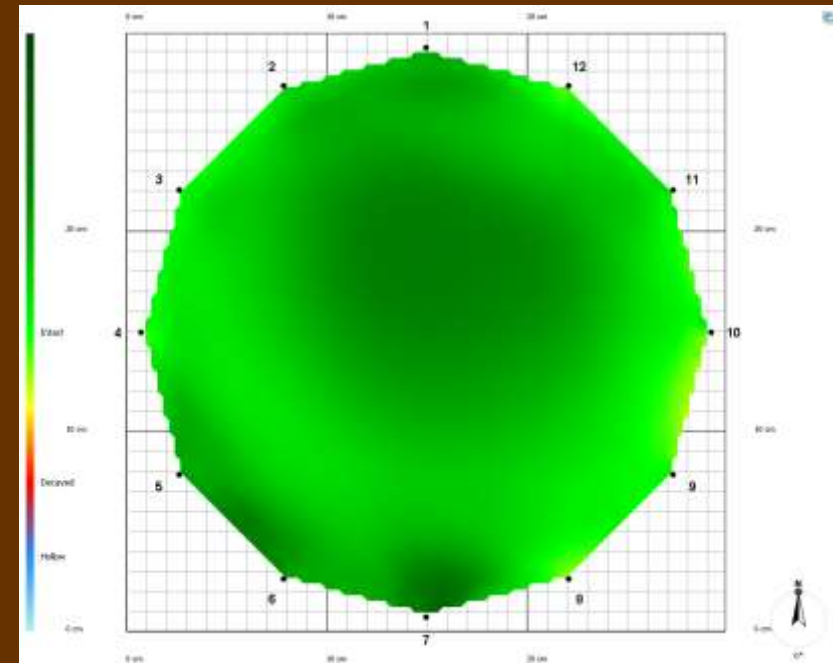
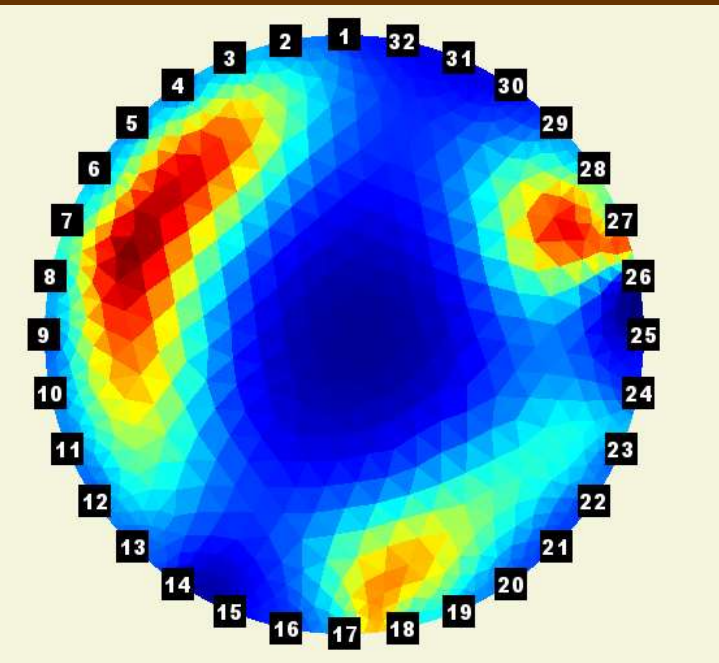
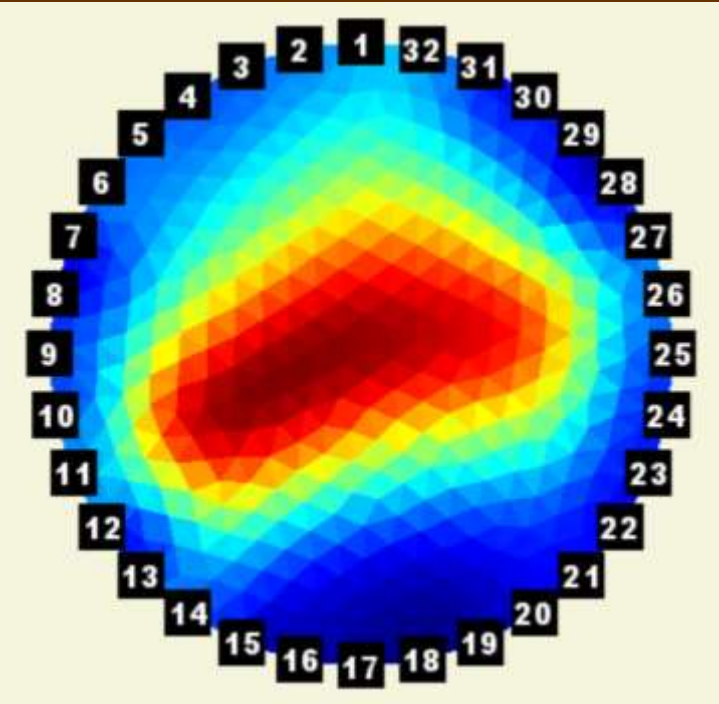




# Healthy (up, left) and attacked (down, left) ash



∞ The acoustic tomogram does not show any decay, while the fungi is already in the middle of the trunk – early stage of fungi attack







🌀 We used to test  
our devices at a big  
beech tree





⌛ Time to time, we  
returned to the tree



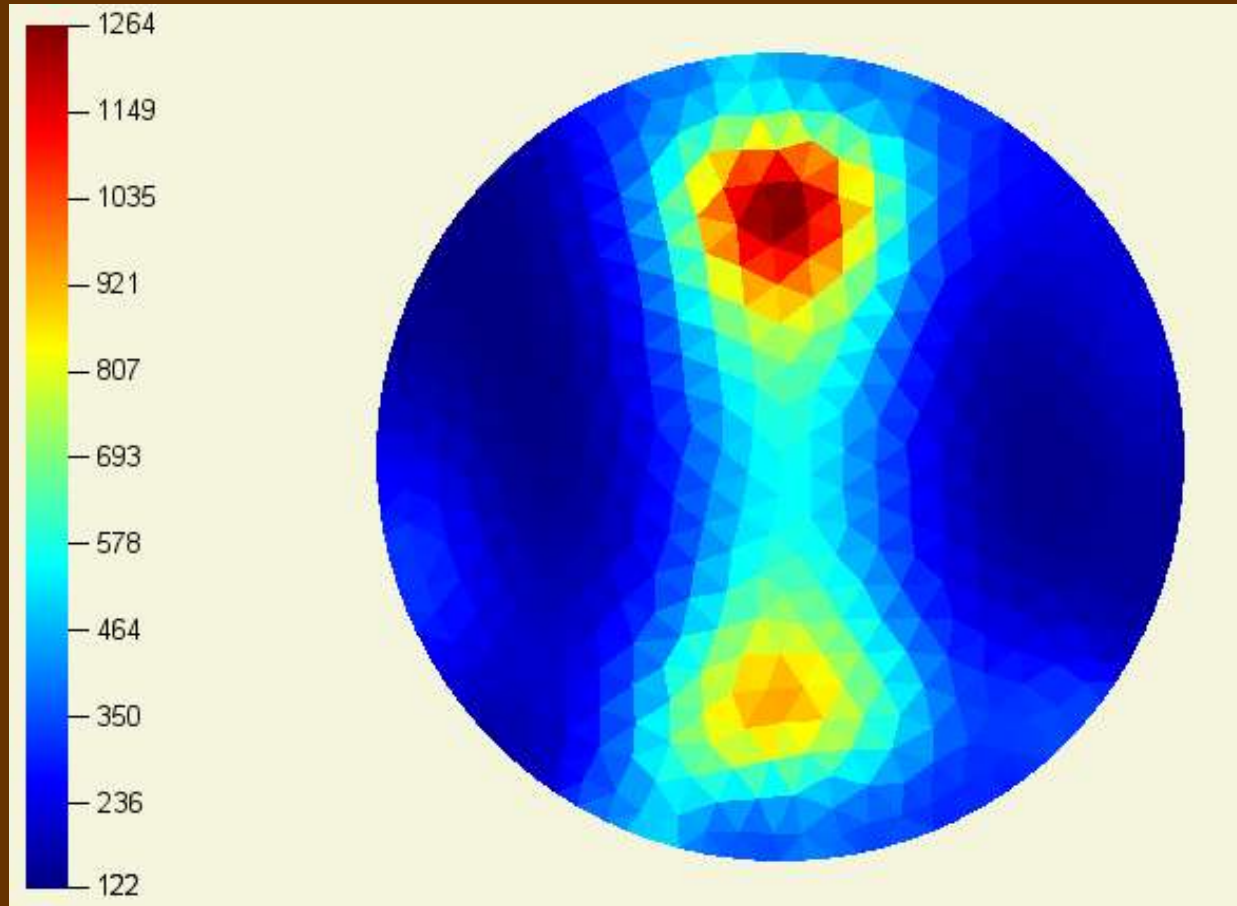




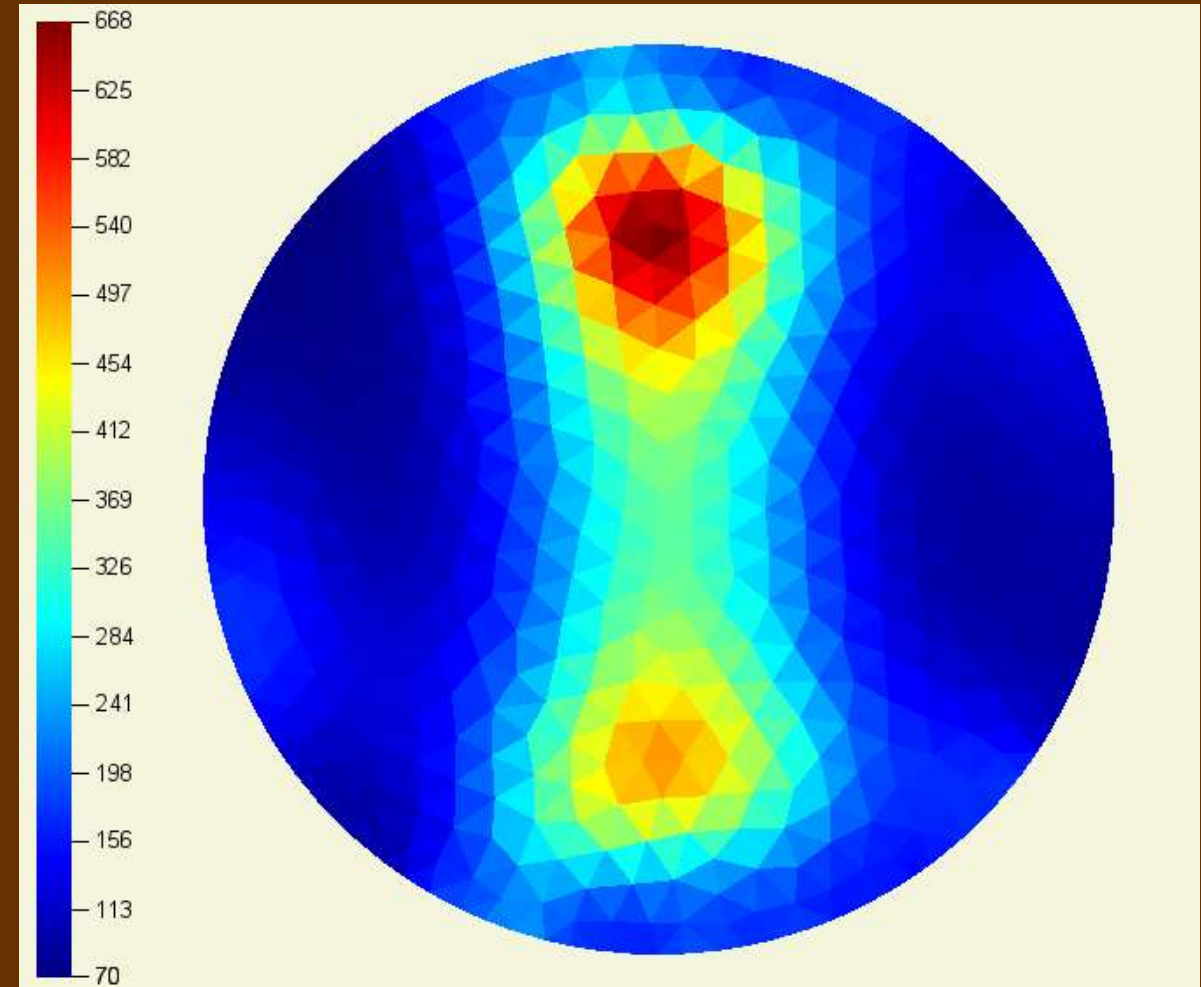
∞ The electrodes are made from stainless steel



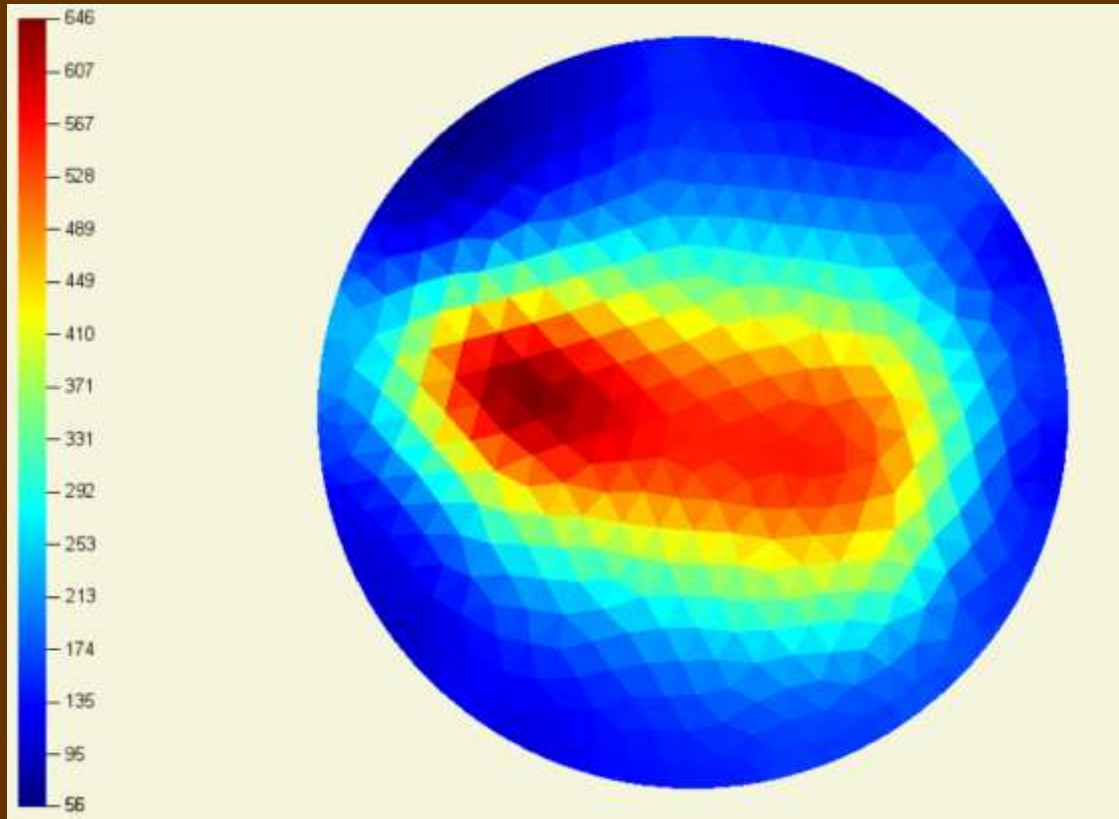




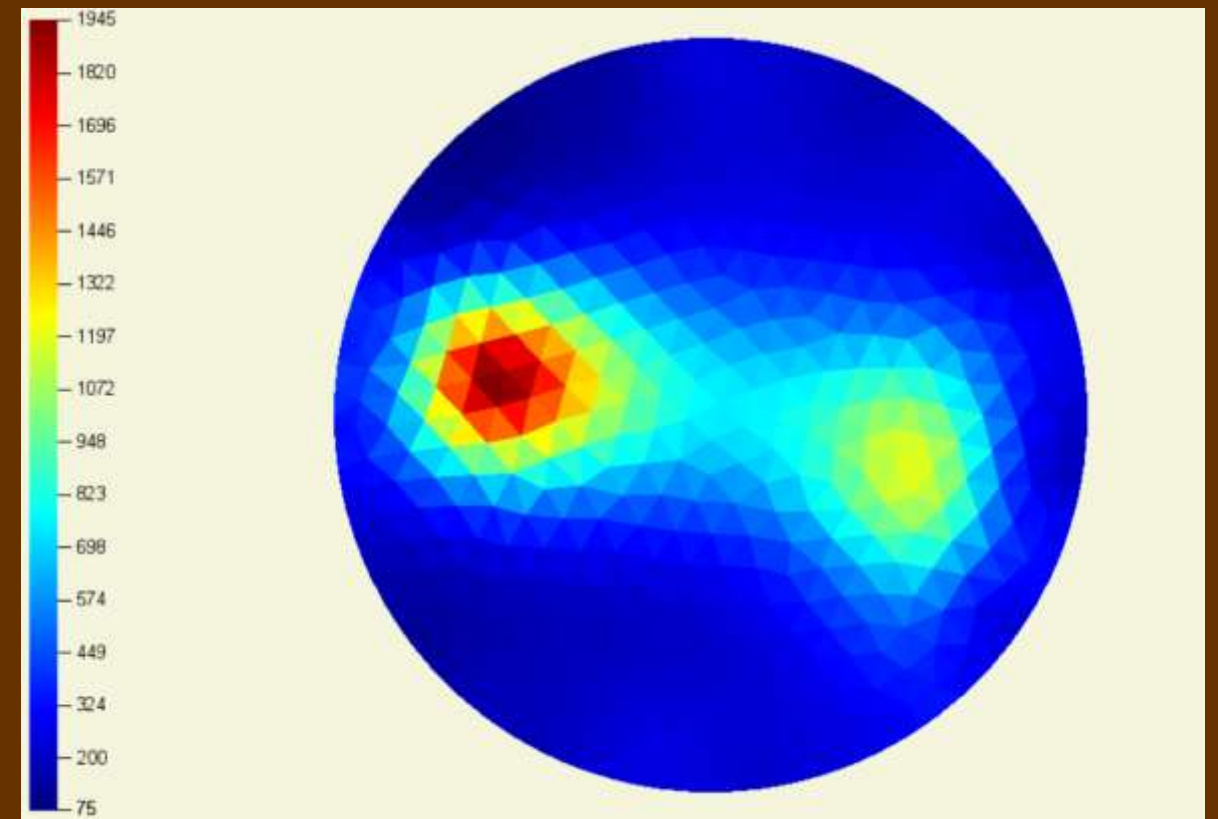
∞ The same pattern appeared time to time



➤ Different setup conditions were tested to see if the pattern on the tomogram stays similar

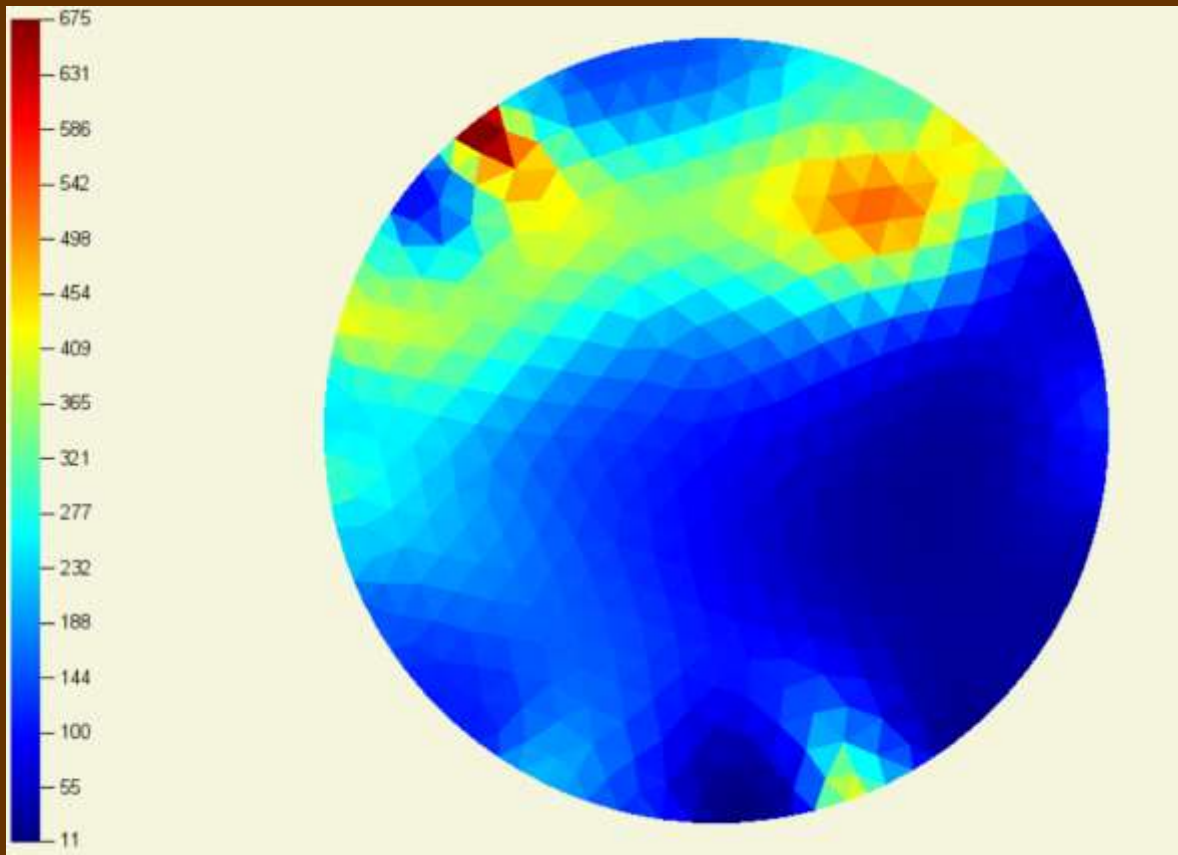


Low battery

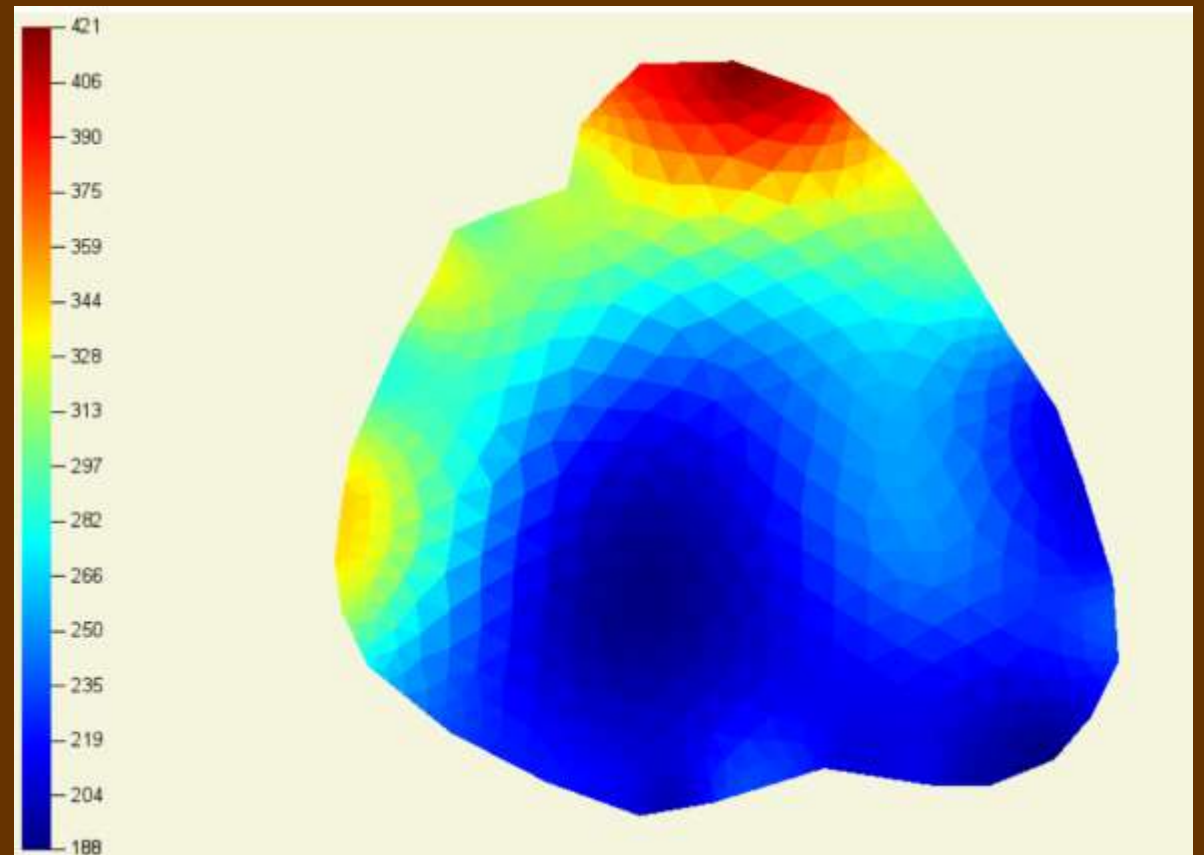


Well-charged battery



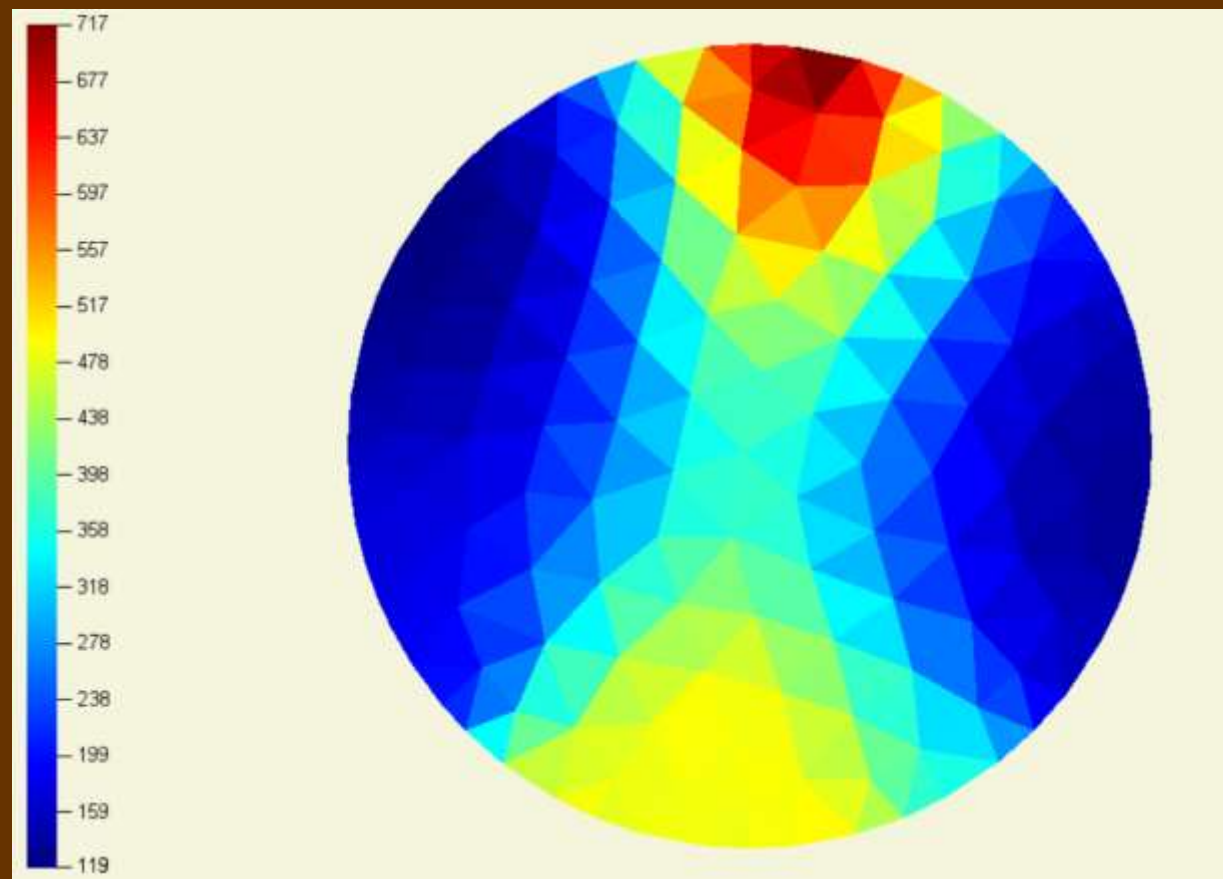


„Lazy geometry”

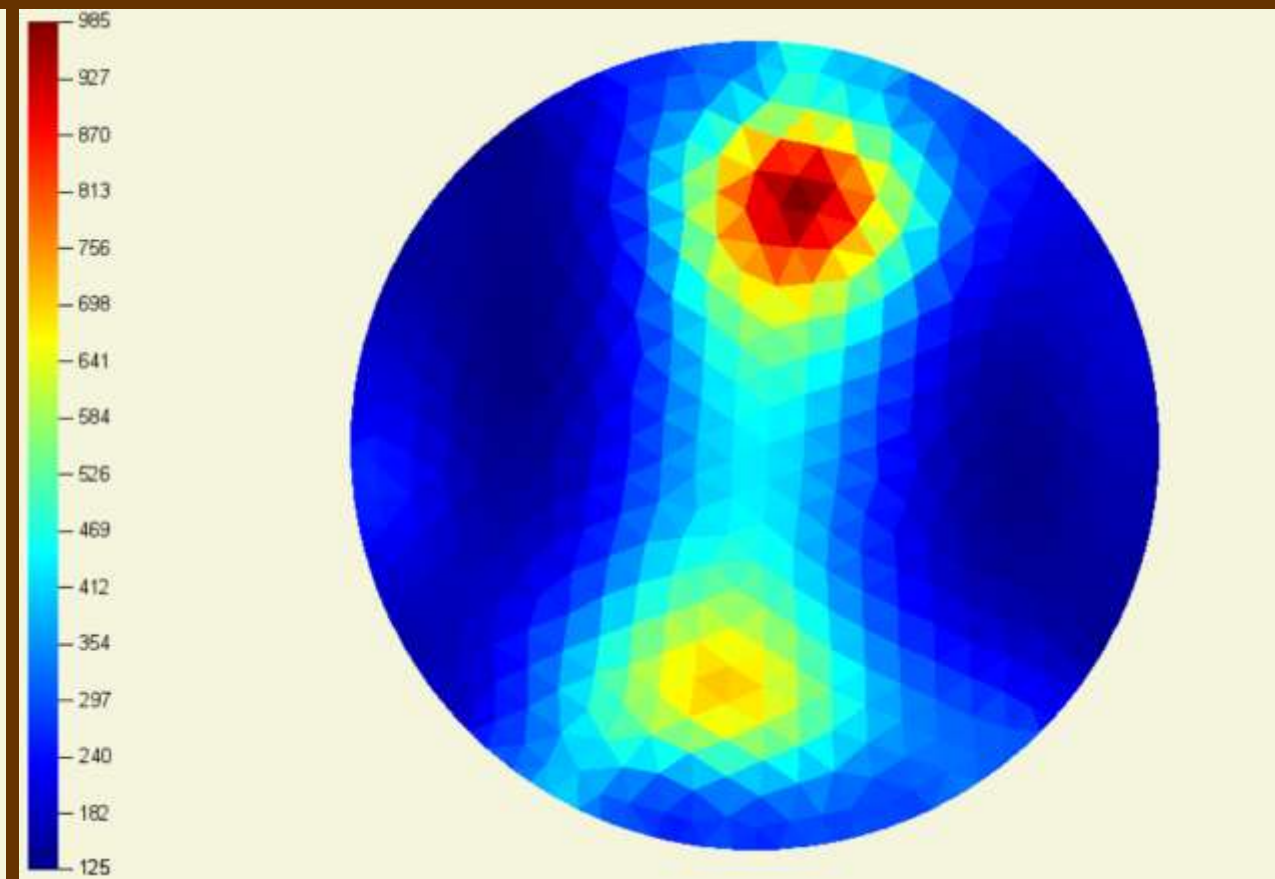


Real geometry





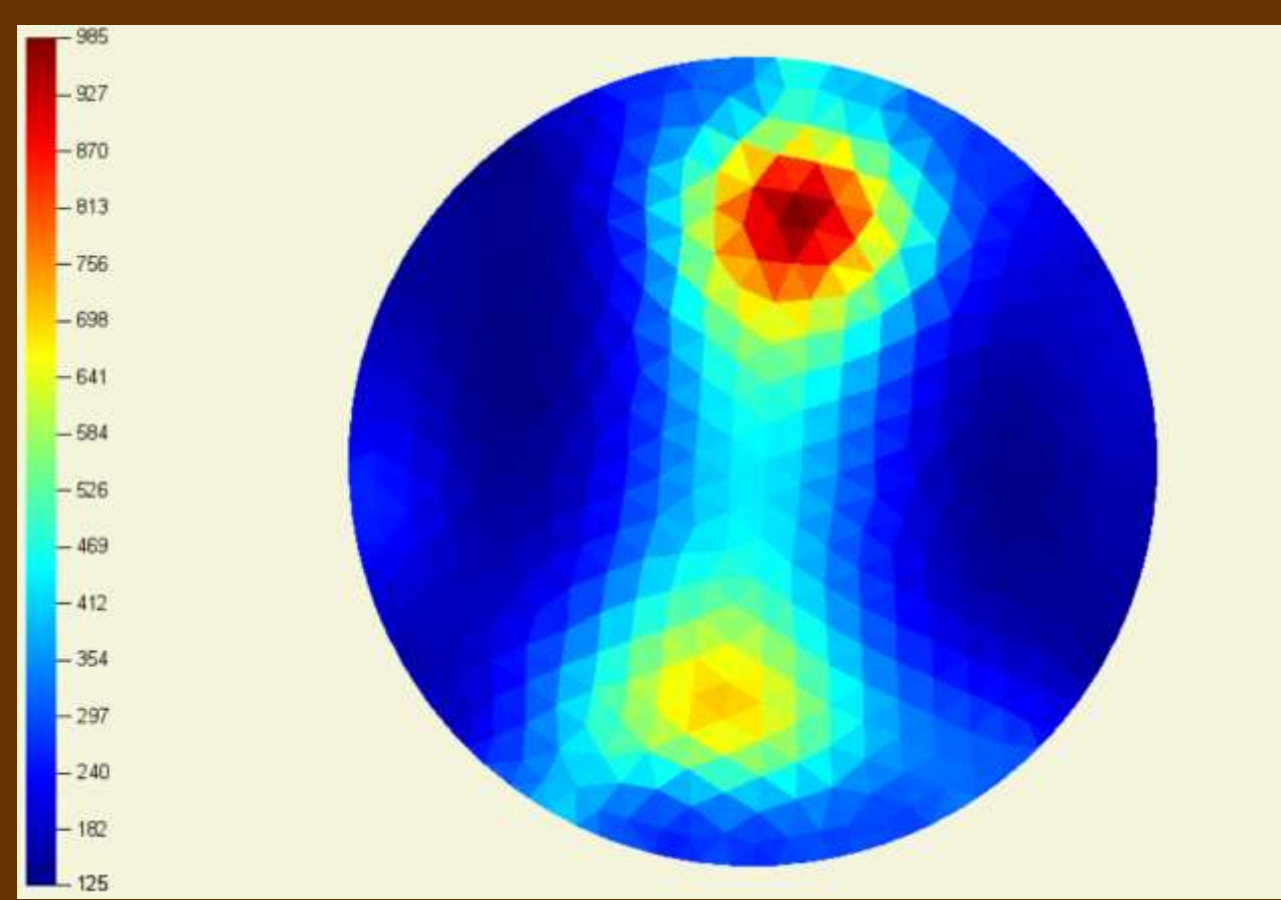
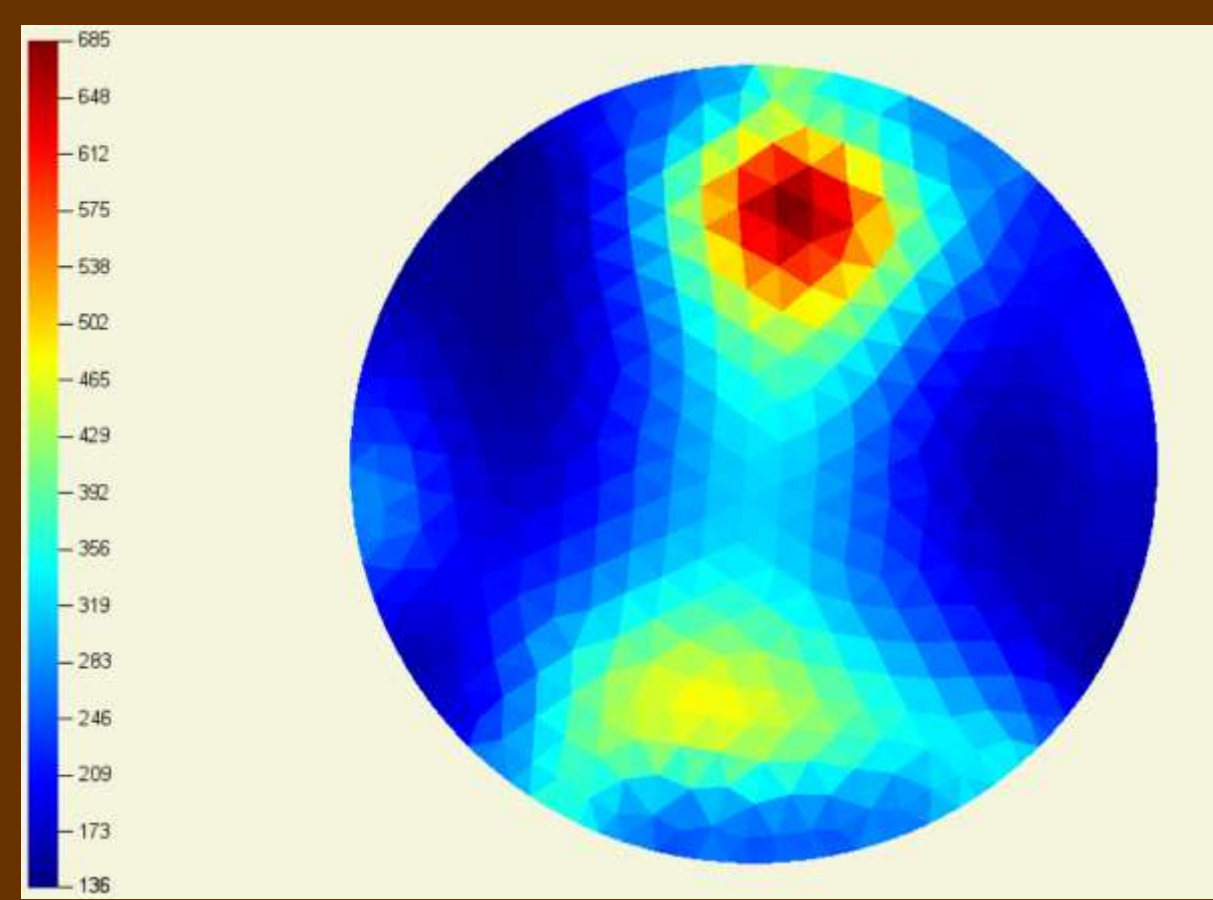
16 electrodes



32 electrodes





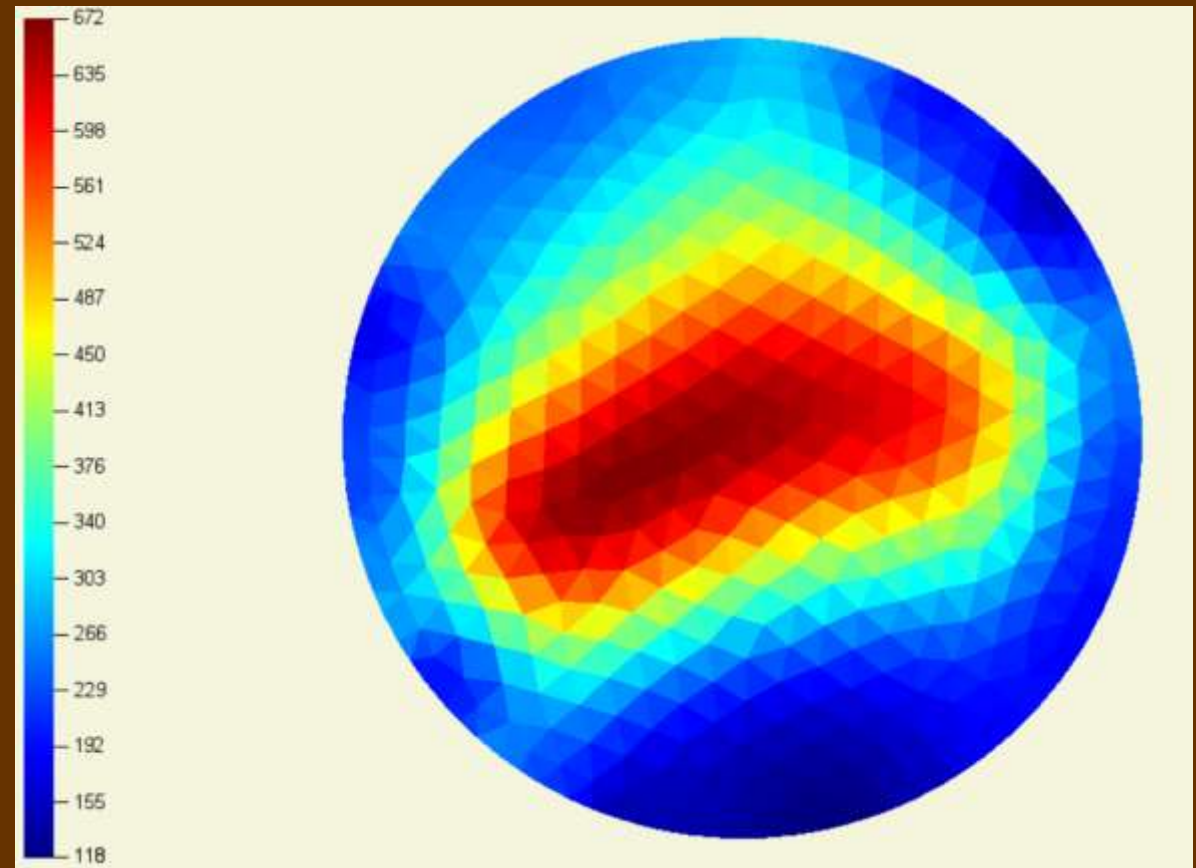
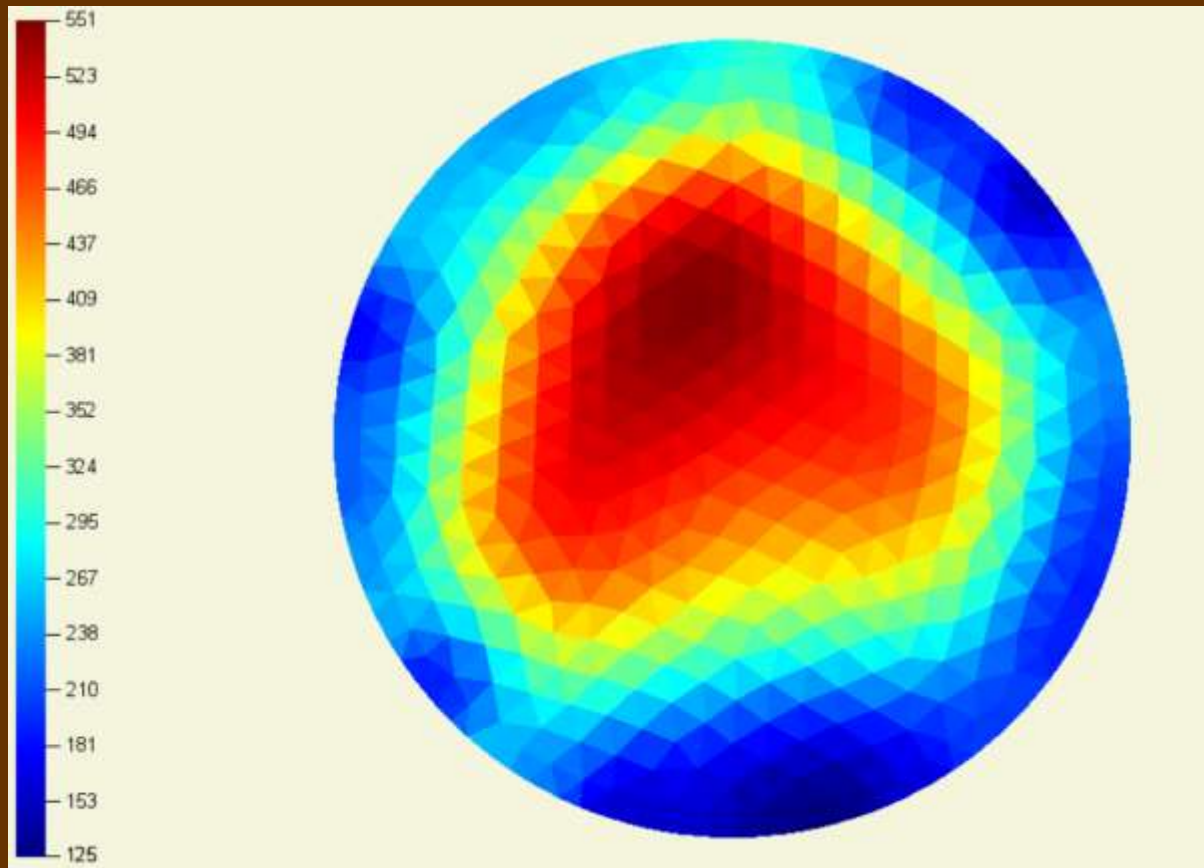


MED; Maximal electrode distance (related to number of elemental measurements)

MED: 7 (224)

MED: 8 (256)





MED; Maximal electrode distance (related to number of elemental measurements)

MED: 5 (160)

MED: 8 (256)

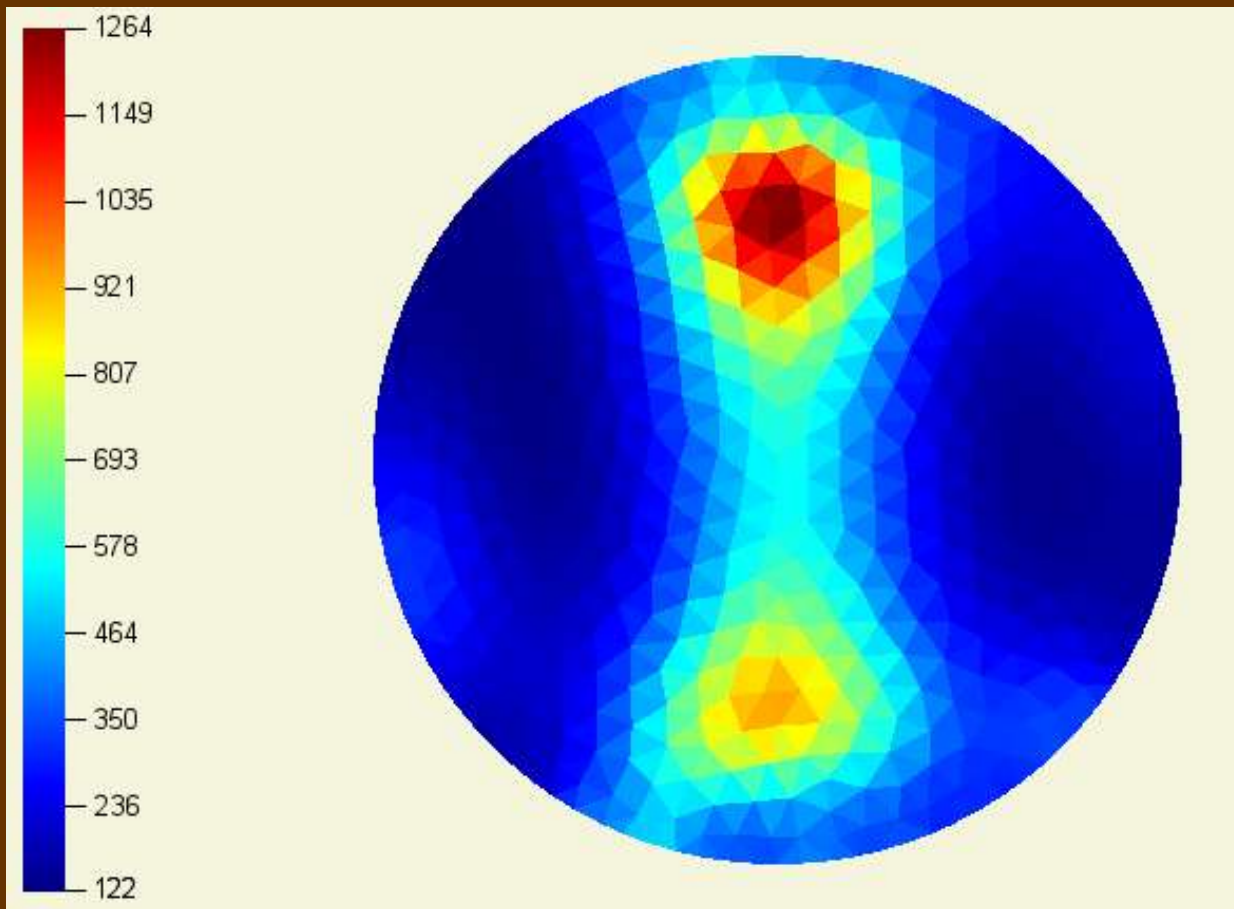


🌀 This measurement was done on an ash tree, not on the big beech

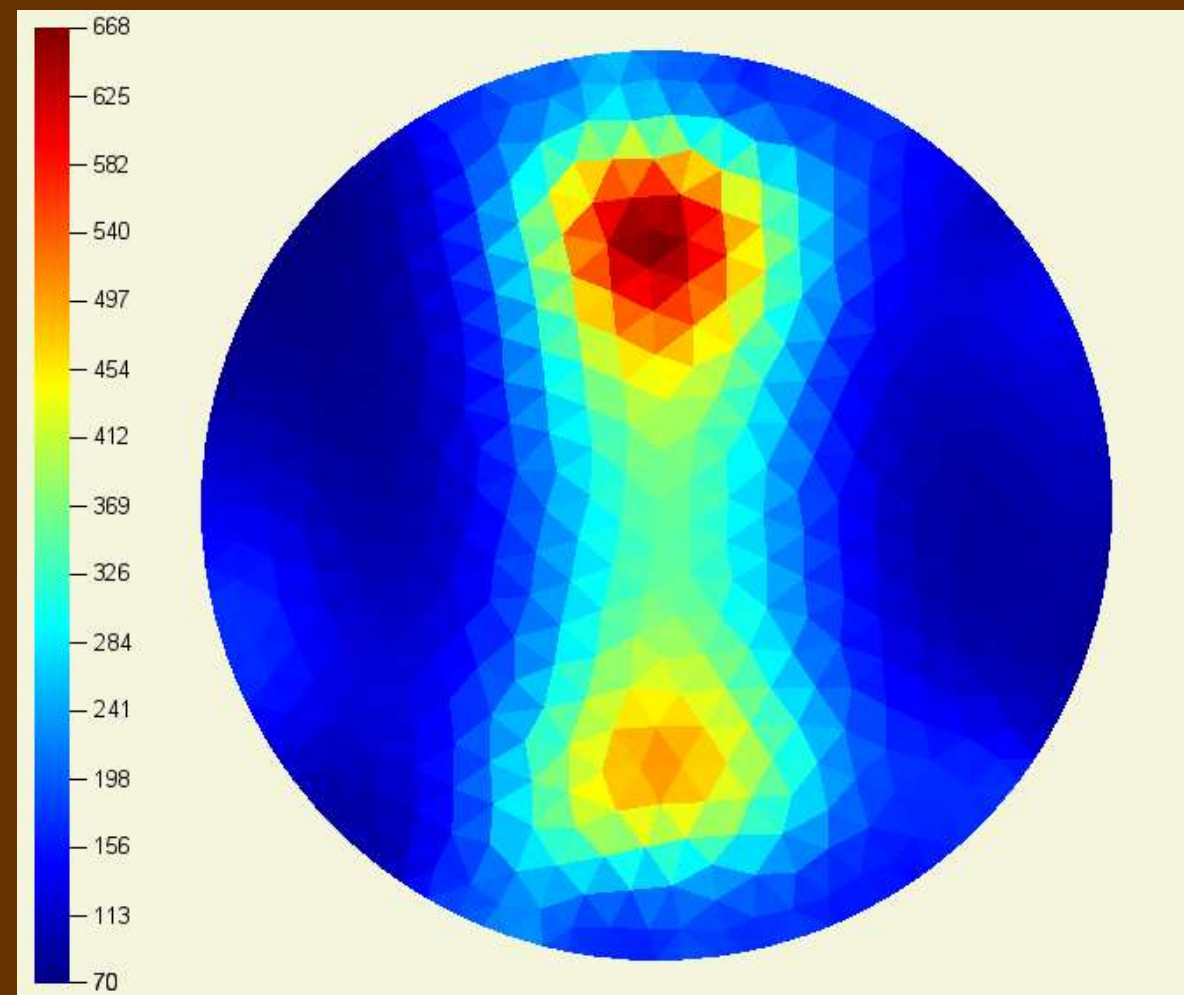




➤ Let's return to the tree



Is this made by the measurement itself?



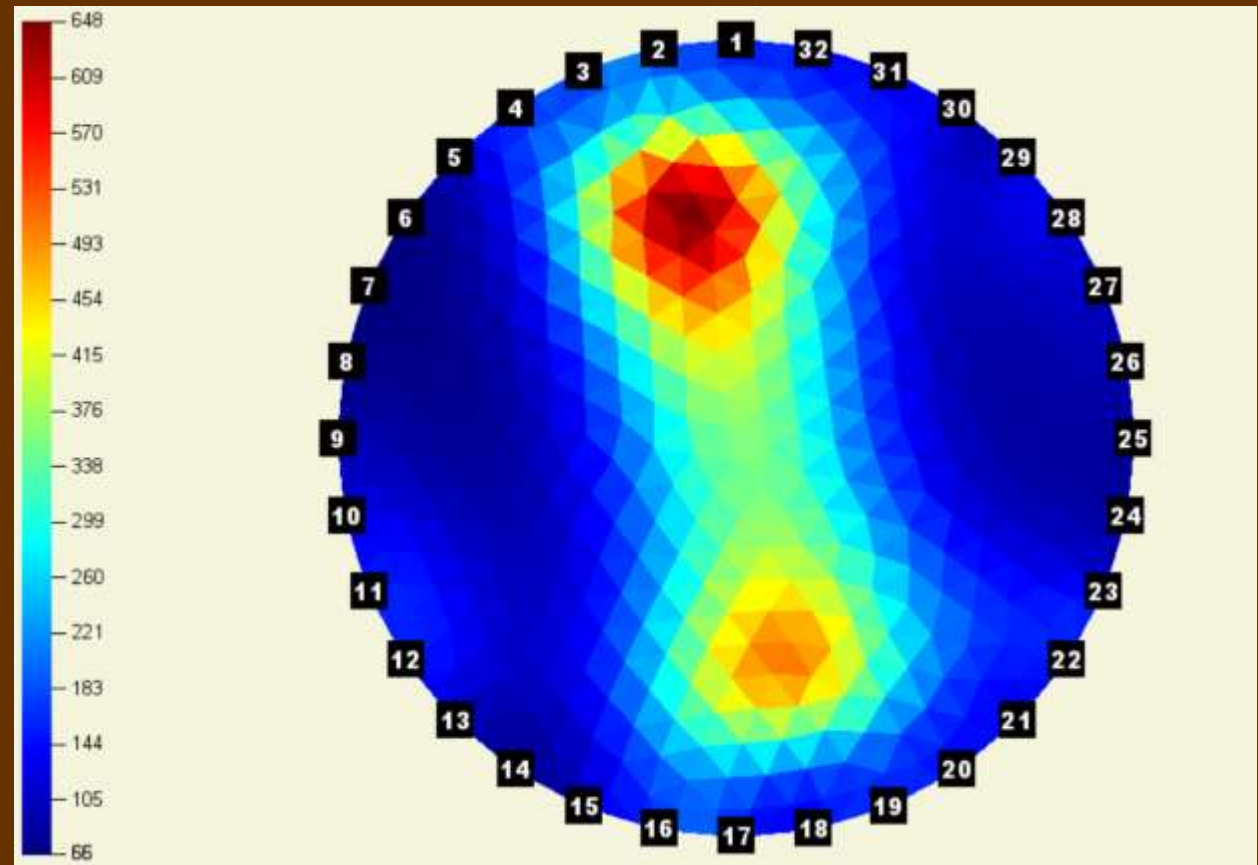
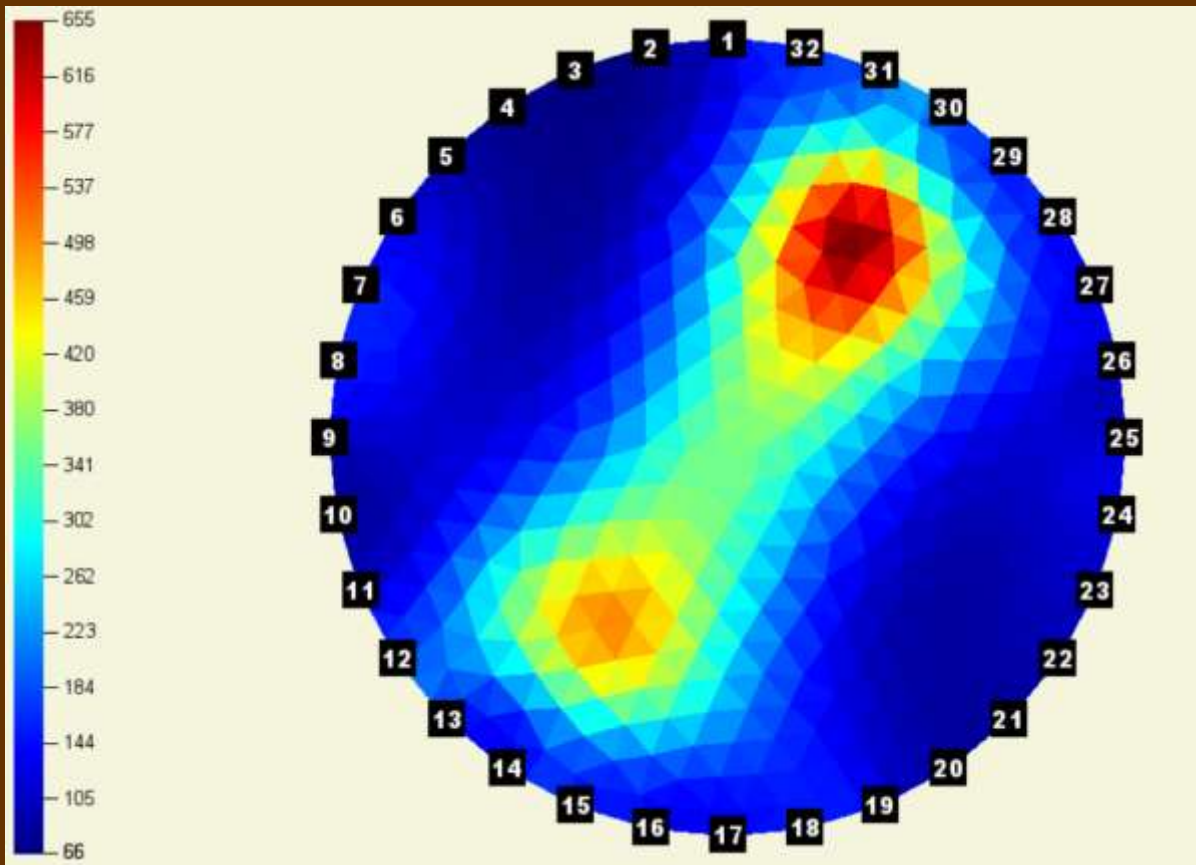




➤ We replaced the crocodile clips with a 4 electrode shift

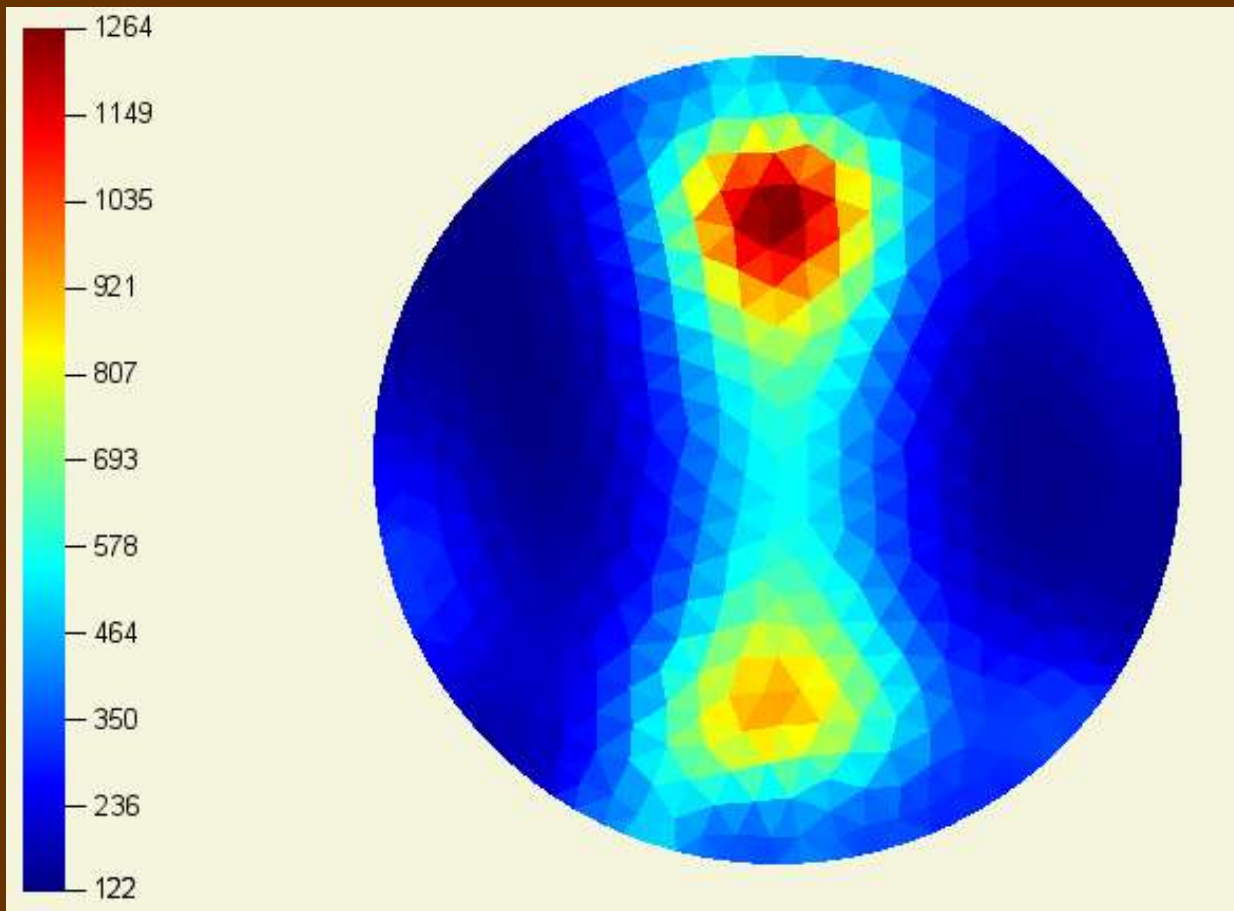


☞ And the pattern rotated



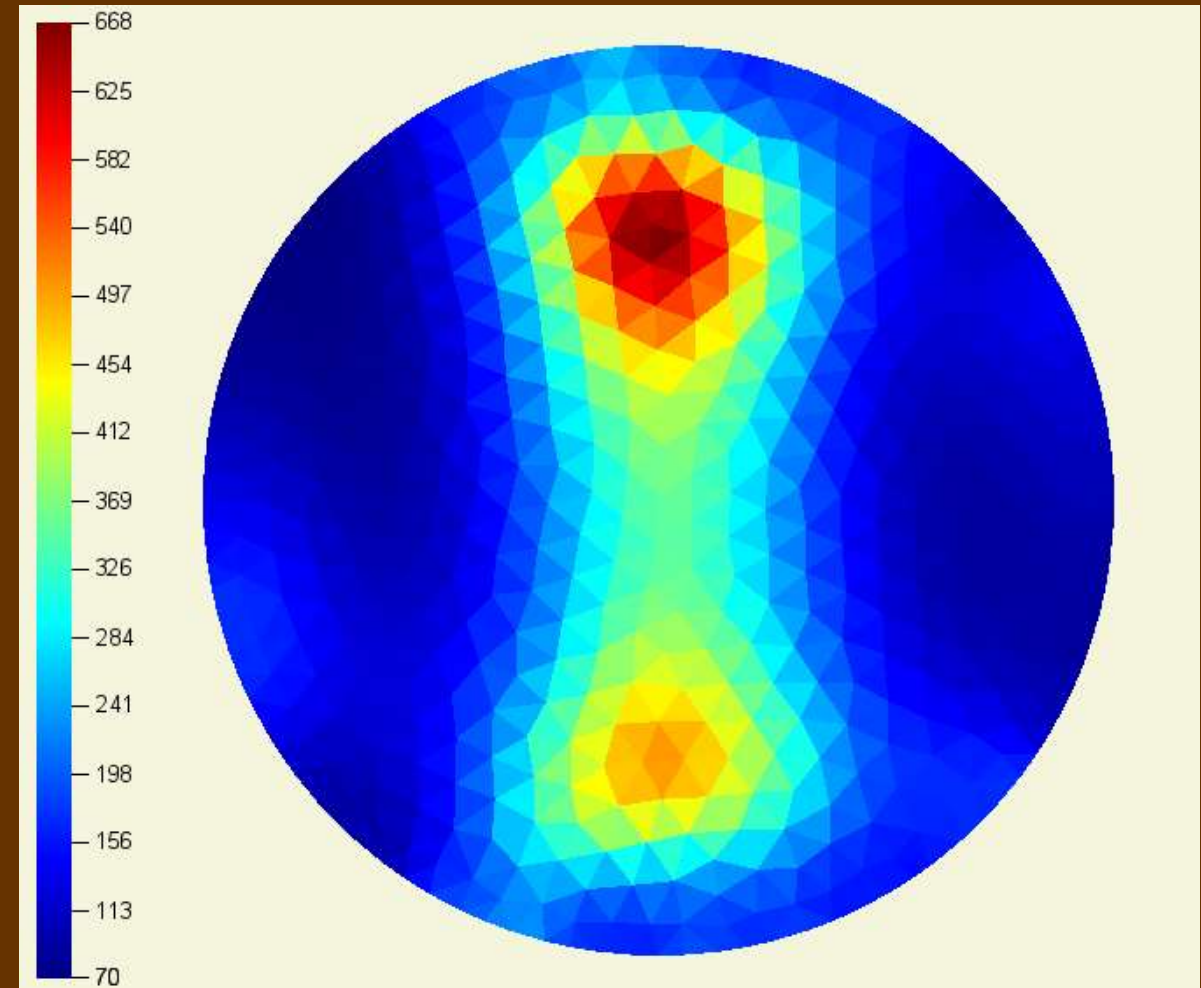
☞ So the pattern is there



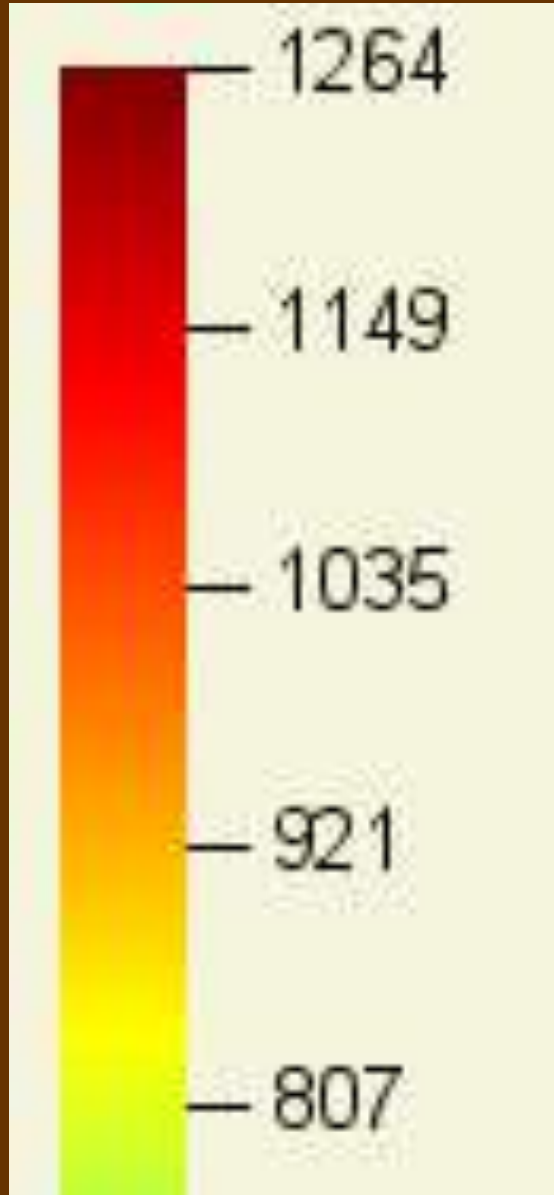


☞ But are they really the same?

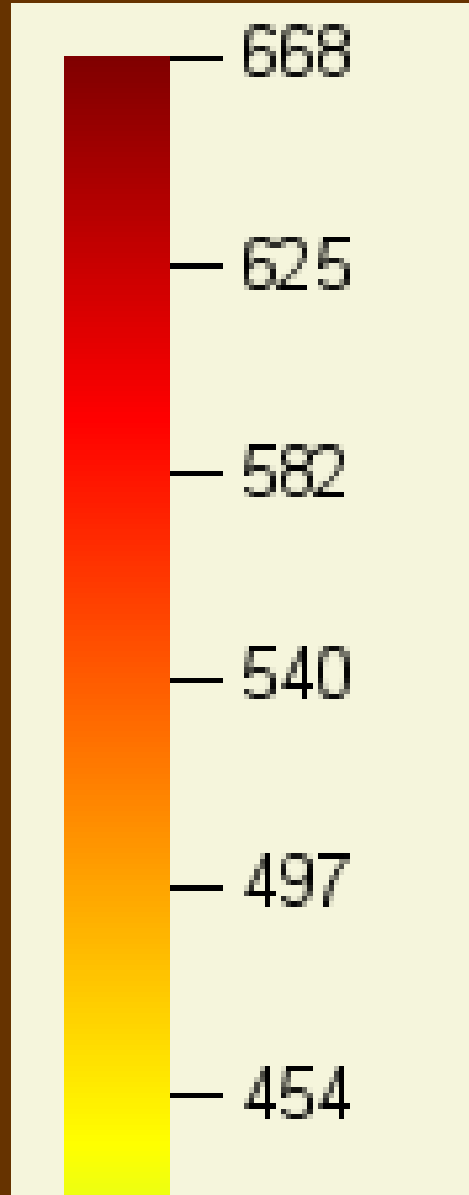
☞ Let's check the scales!



$\Omega * \text{meter}$

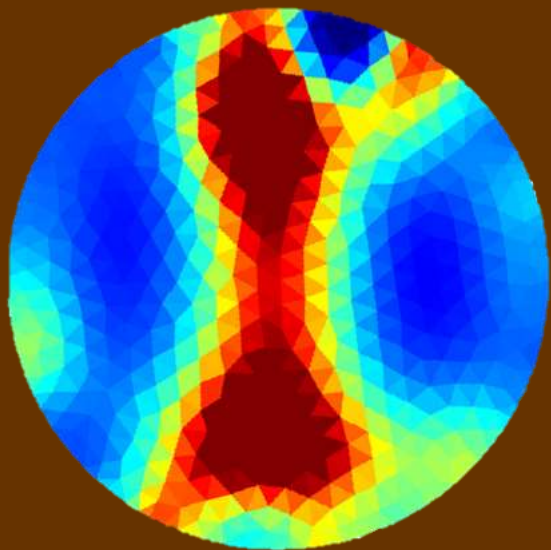


$\Omega * \text{meter}$

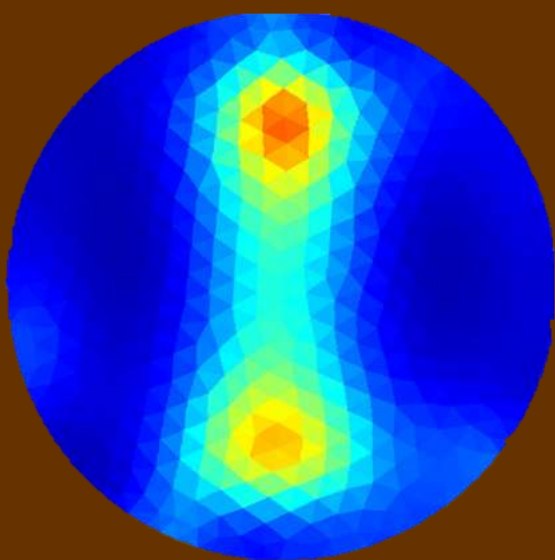


- ∞ The scales should be the same
- ∞ Let's see the tomograms with a scale 50-750

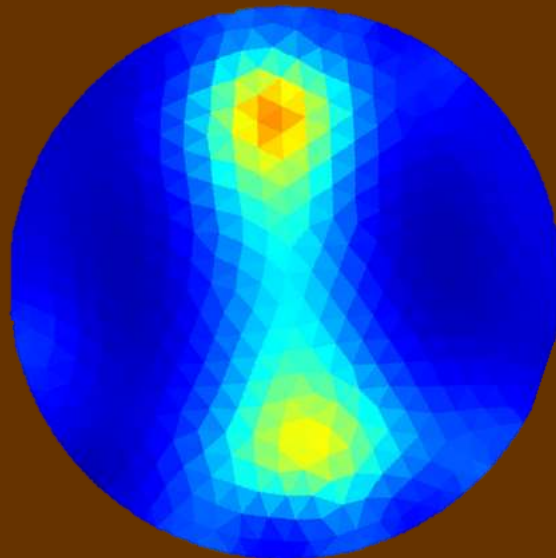




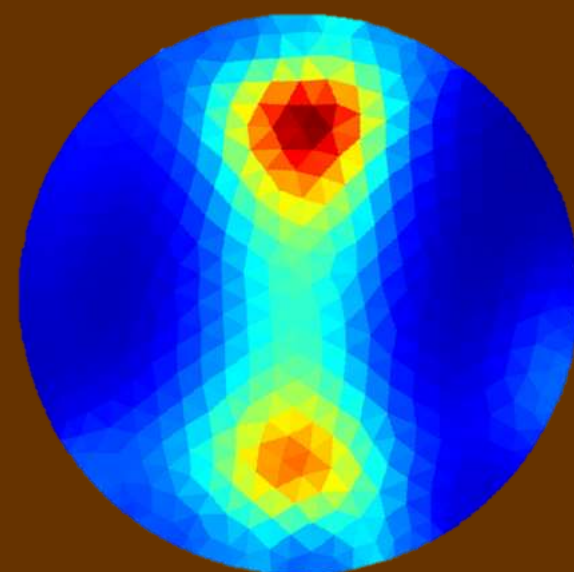
2018 March



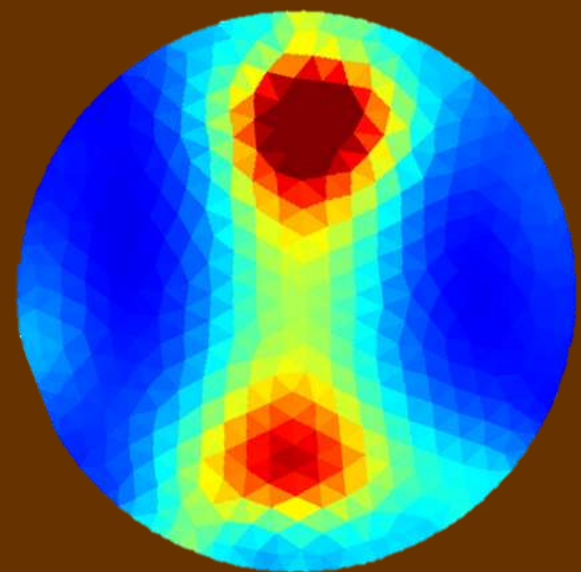
May



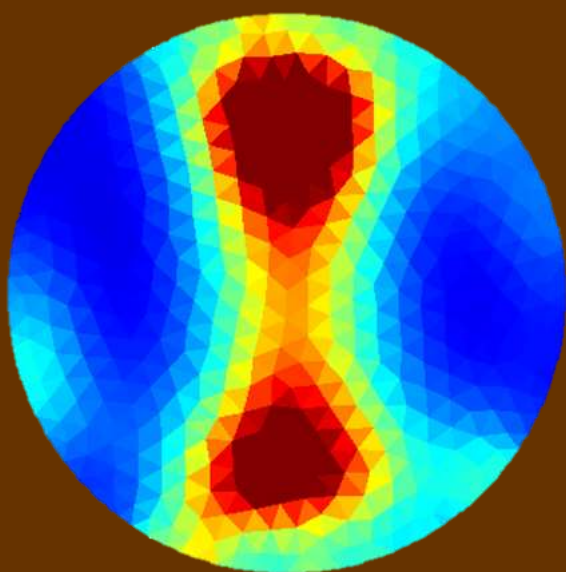
July



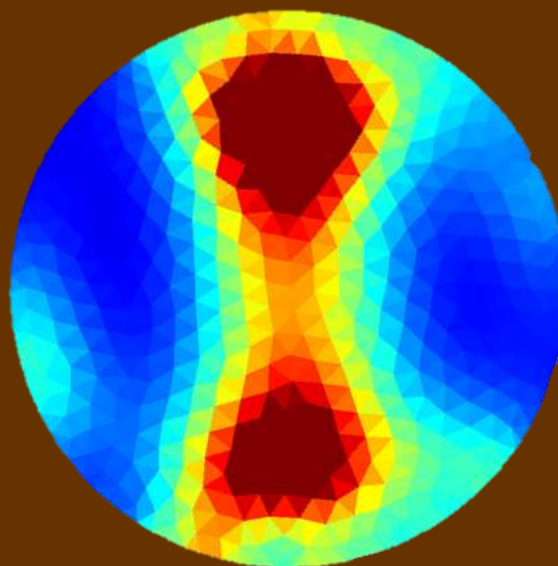
October



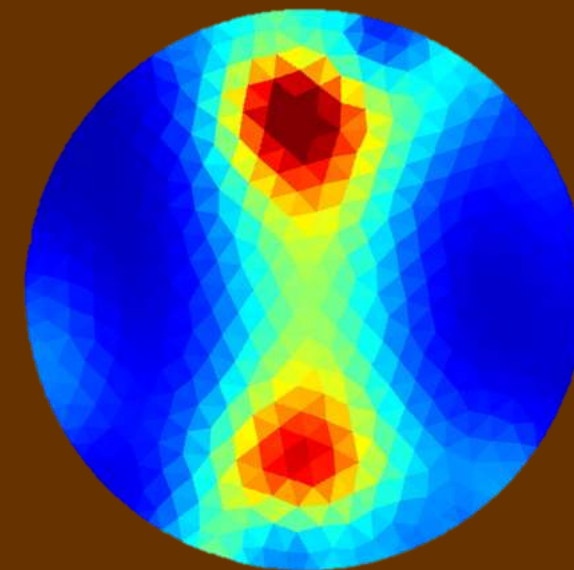
2018 December



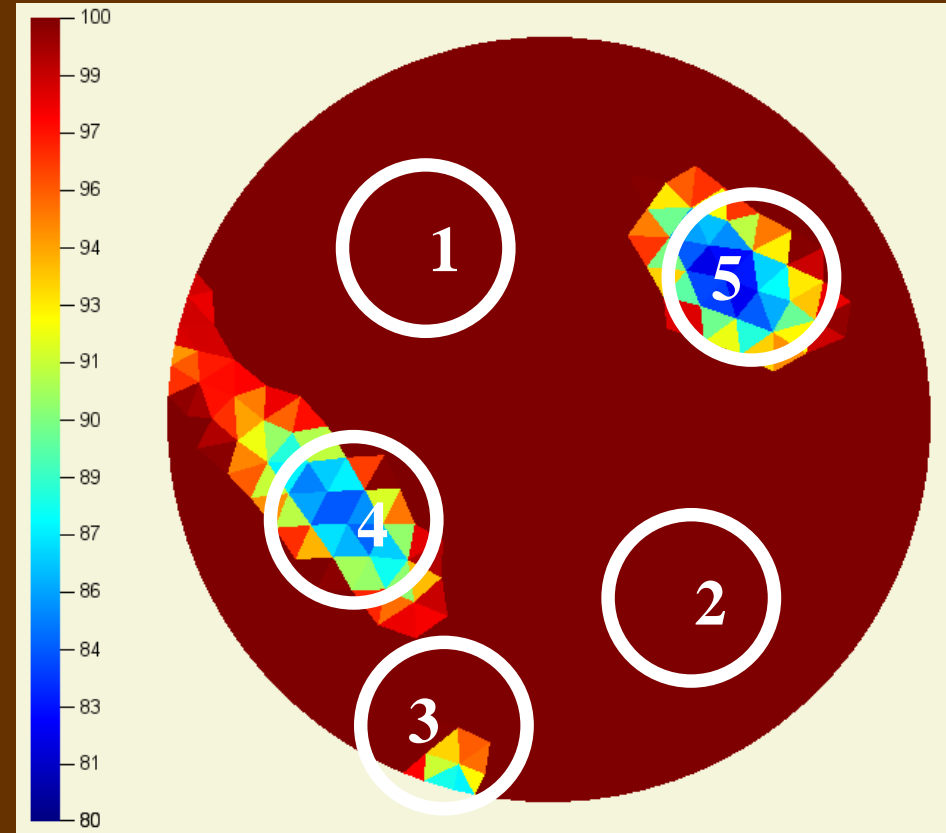
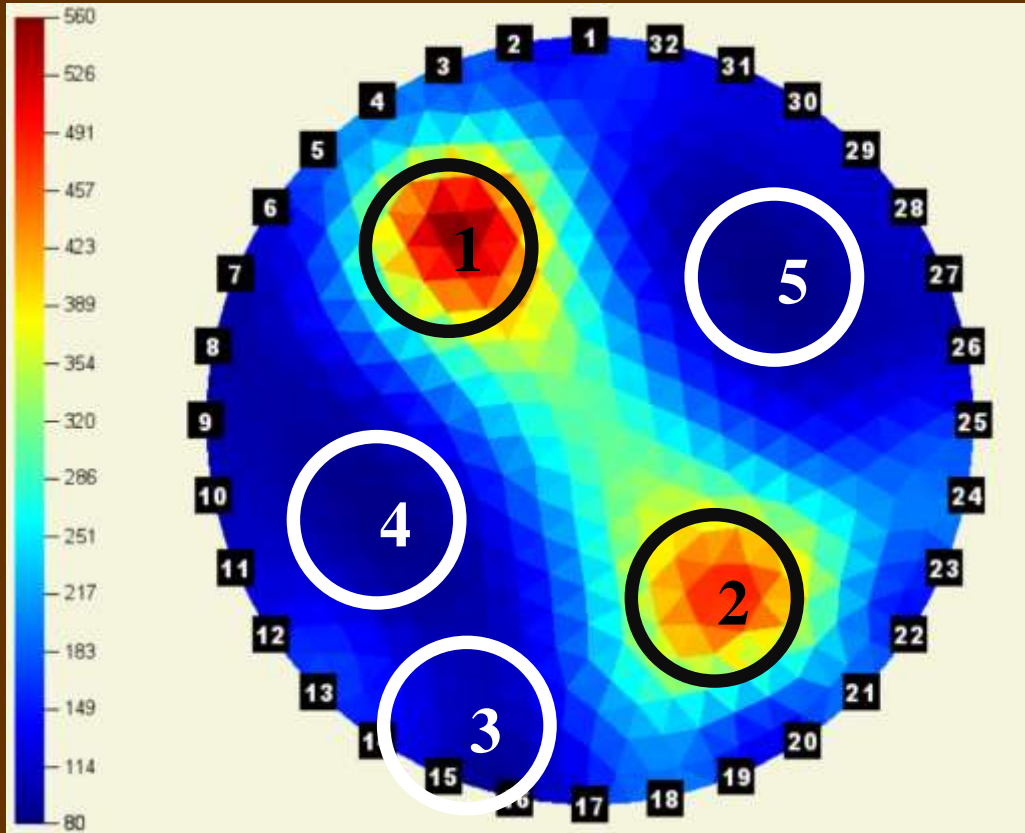
2019 January



February



March



↪ 5 area were selected, and the averages were calculated

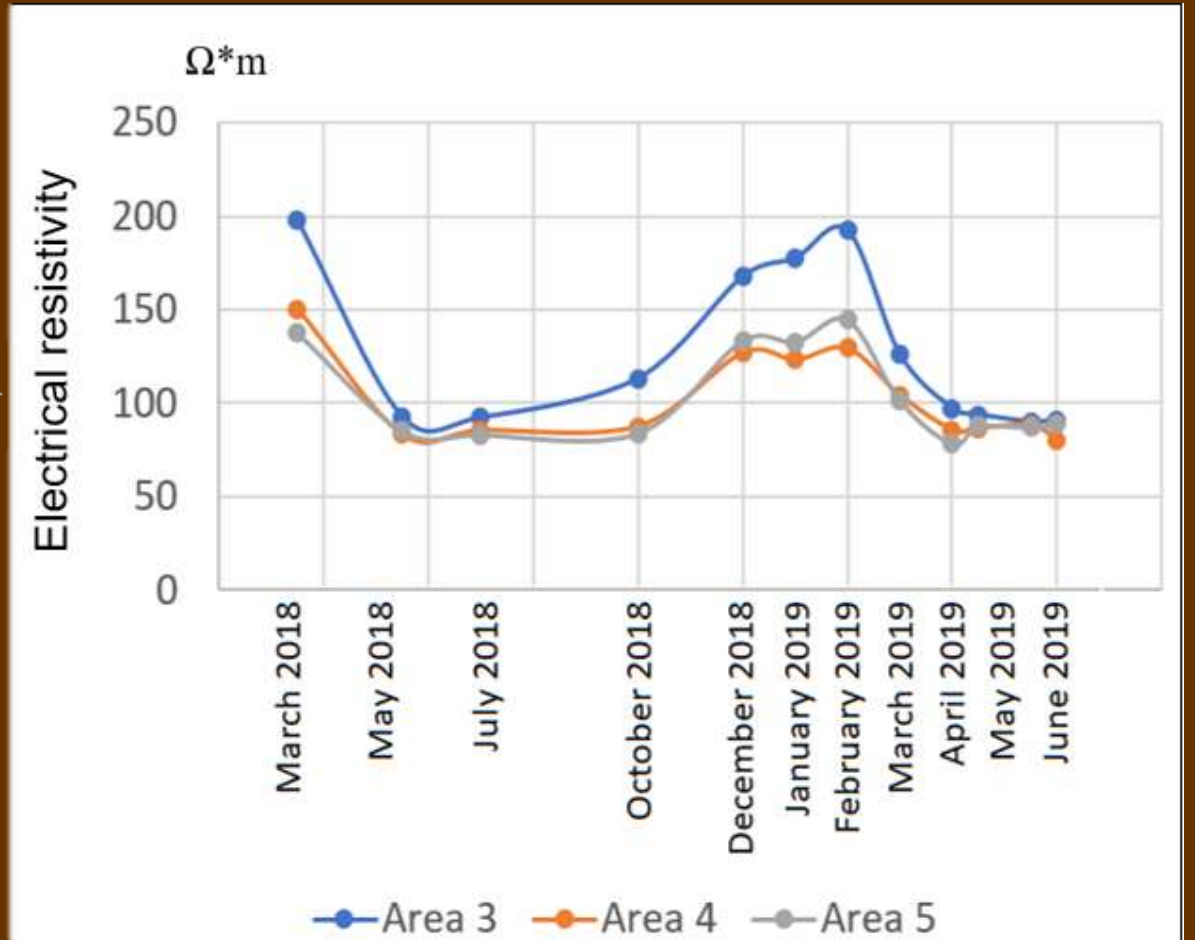
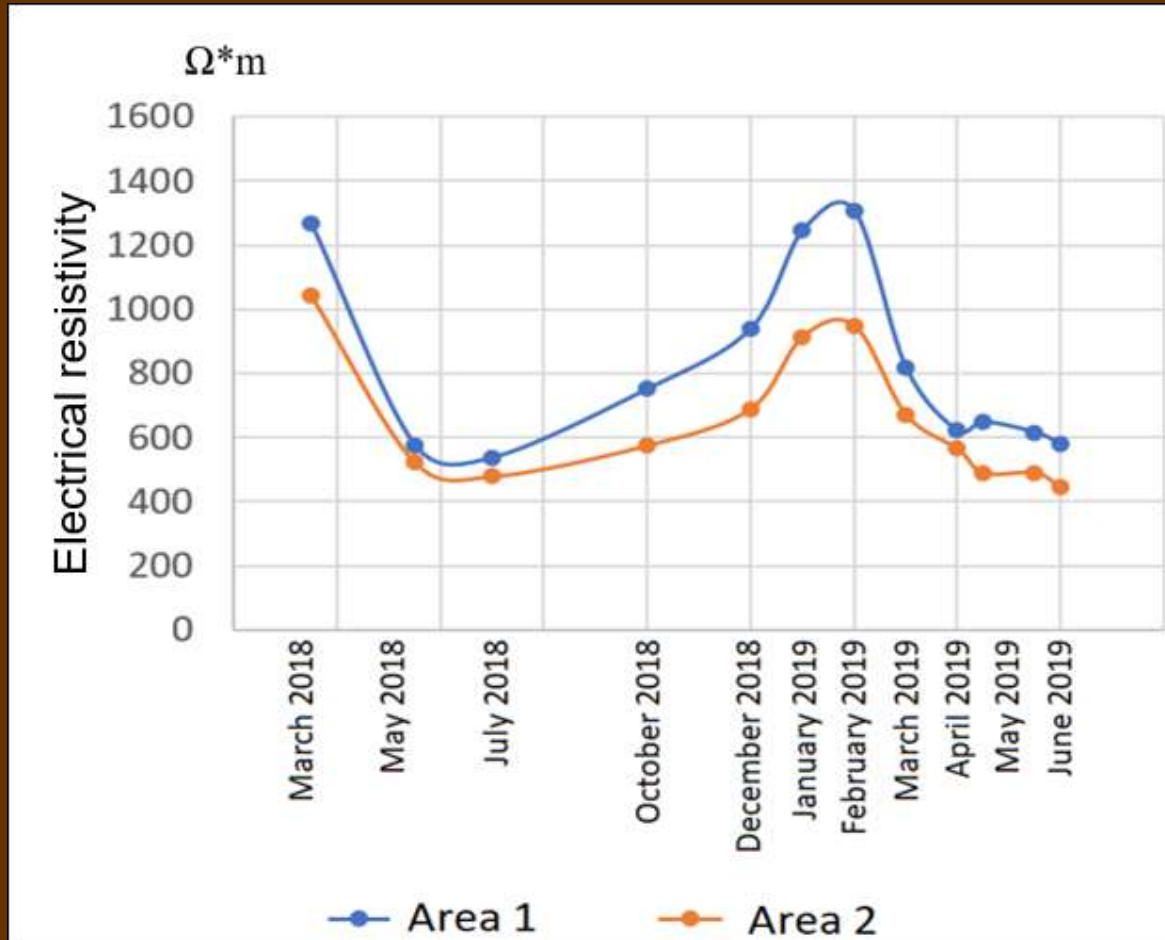




**Table 1—Date, temperature and electric resistivity values in the selected areas**

Date	Temperature (°C)	Resistivities ( $\Omega \cdot m$ )						
		Area 1	Area 2	Area 3	Area 4	Area 5	Min	Max
23/03/2018	2.4	1265.8	1039.9	197.7	150.2	137.1	28.2	1332.4
24/05/2018	21.1	575.7	521.2	92.3	83.2	85.0	82.3	595.3
02/07/2018	16.8	536.7	477.6	92.0	85.2	82.9	82.1	562.2
11/10/2018	16.7	751.0	574.4	113.0	87.5	83.8	72.5	778.7
10/12/2018	6.5	939.3	689.1	167.8	126.8	133.3	125.1	984.8
07/01/2019	-0.2	1245.3	913.9	177.6	123.1	132.4	121.7	1263.6
07/02/2019	1.6	1308.1	948.8	192.4	129.2	144.2	127.2	1350.0
06/03/2019	9.9	817.6	670.7	125.8	104.1	101.0	84.8	844.9
04/04/2019	13.1	620.8	564.3	97.0	85.6	78.3	66.9	647.1
24/04/2019	16.6	648.4	489.2	93.7	86.5	87.5	70.3	667.5
23/05/2019	16.2	615.4	490.1	89.7	88.1	87.0	66.4	626.7
12/06/2019	27.0	579.2	443.6	91.0	80.4	88.7	61.7	602.9

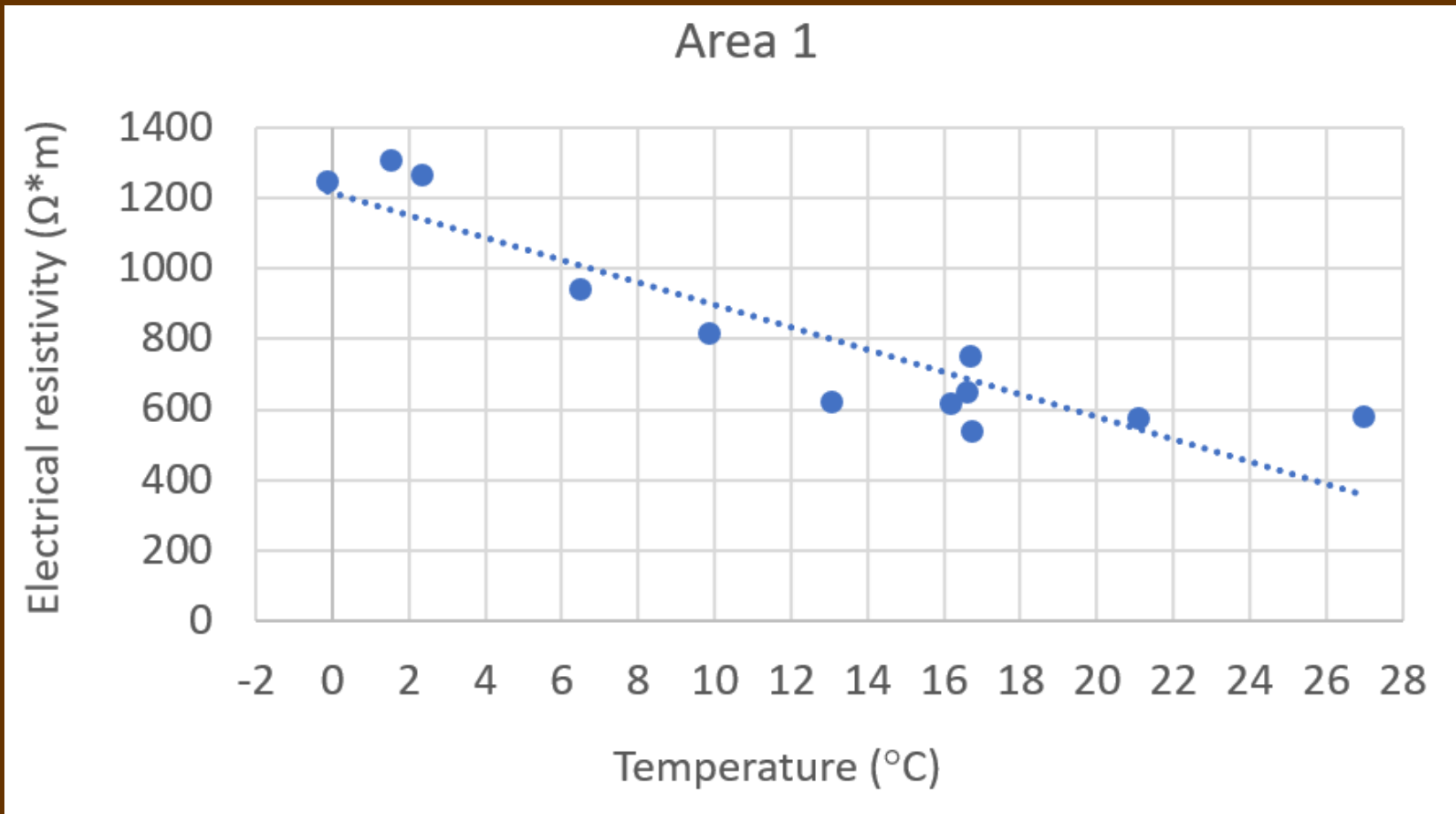
Seasonally changes can be seen







✧ Resistivity depends on temperature,  $R^2$  is 0.82



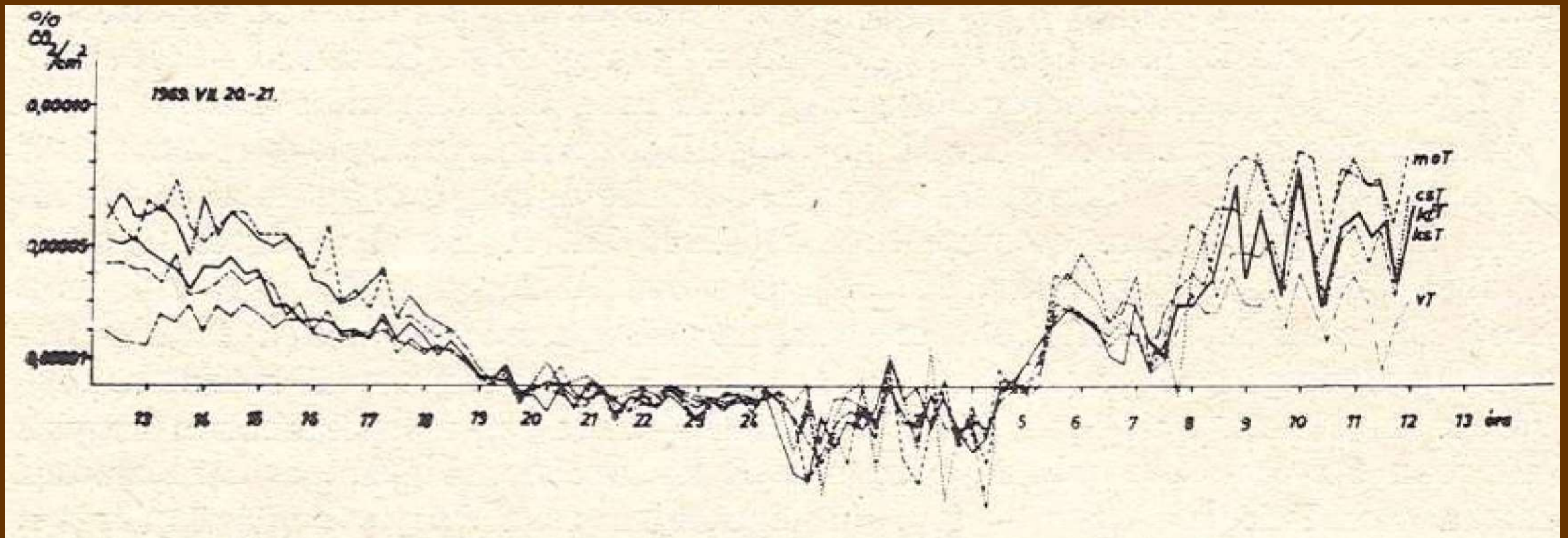
Long-term stability  
was proven





☞ Is there daily effects that could be seen?





↪ Gas emission of oak sapling

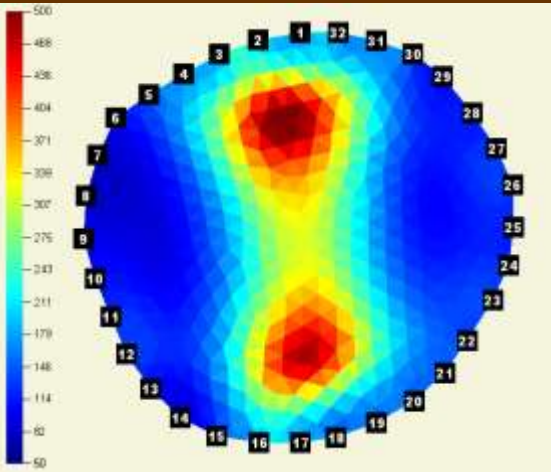
↪ Can we catch it?



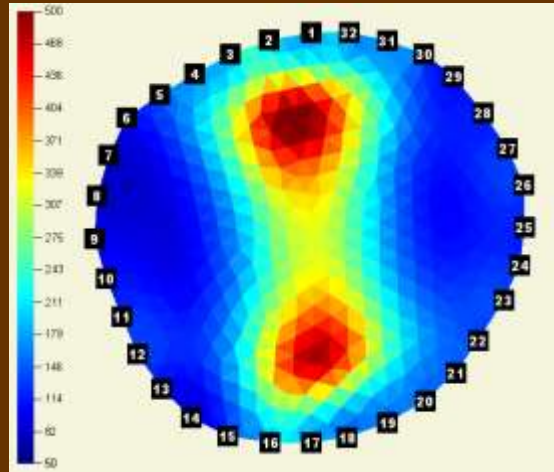


- ↻ Same beech tree
- ↻ 25-hours measurement

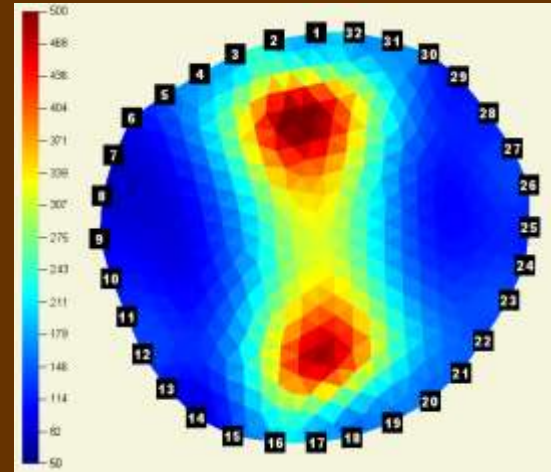




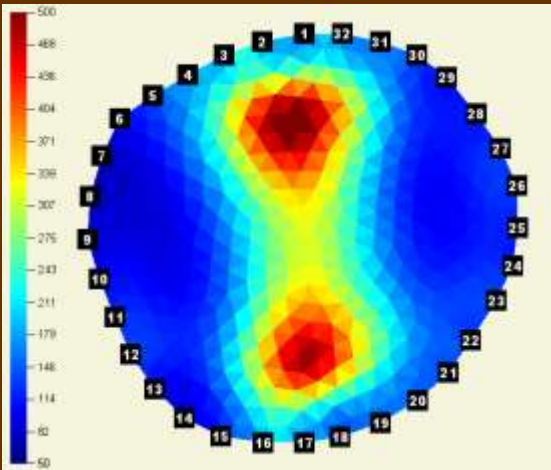
11 pm



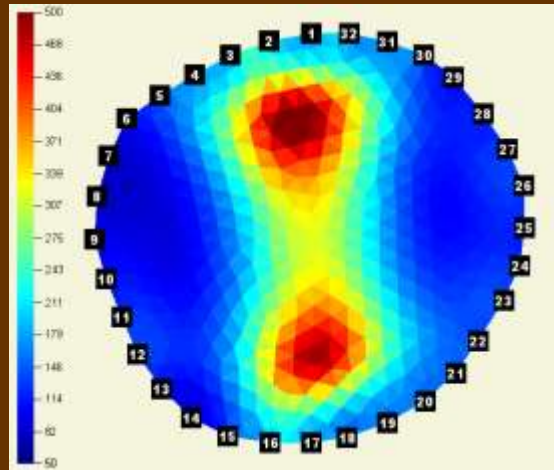
midnight



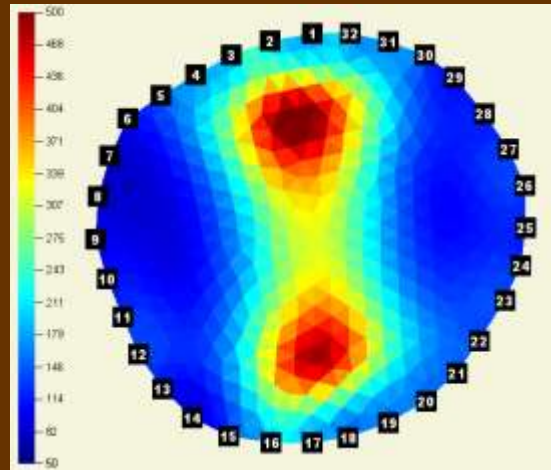
1 am



2 am



3 am

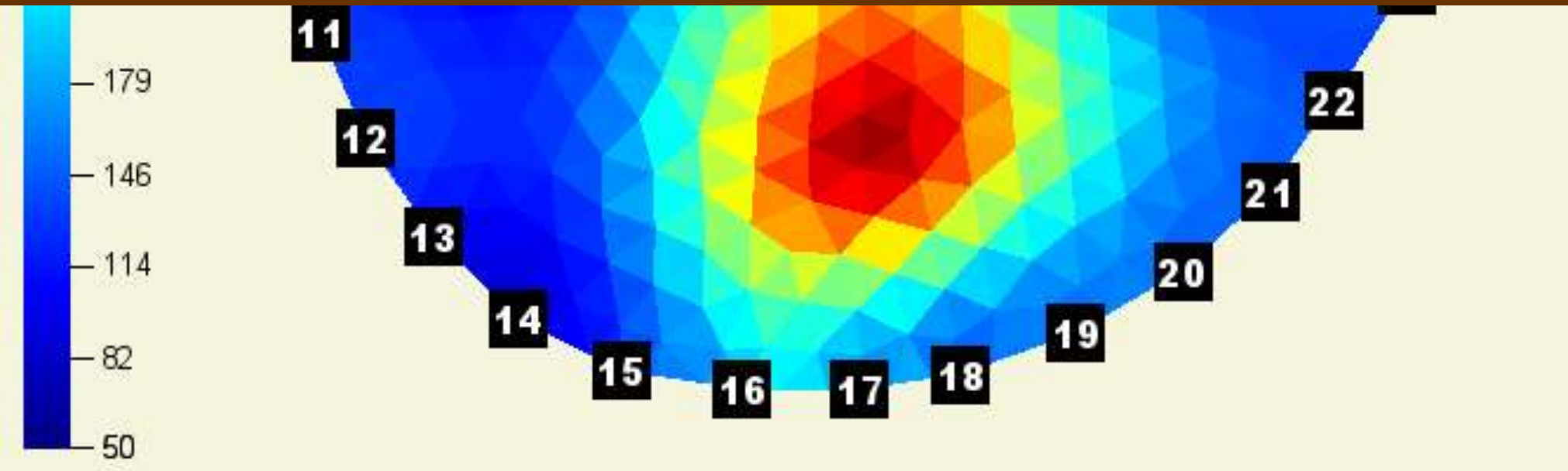


4 am

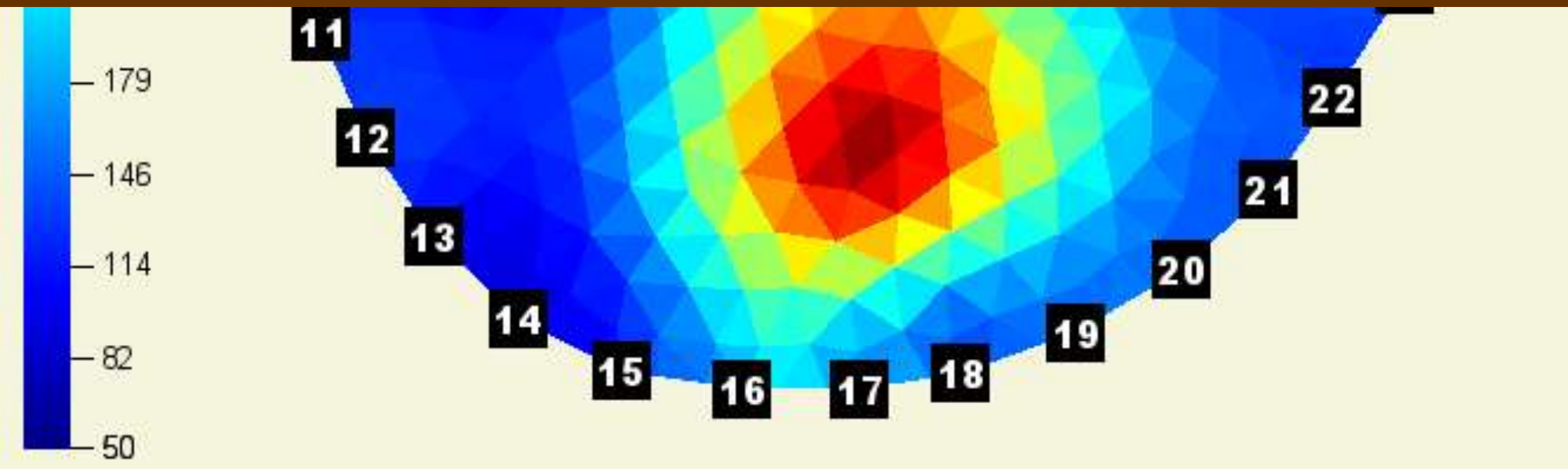
∞ Some tomograms

∞ Not a lot  
difference for the  
first sight

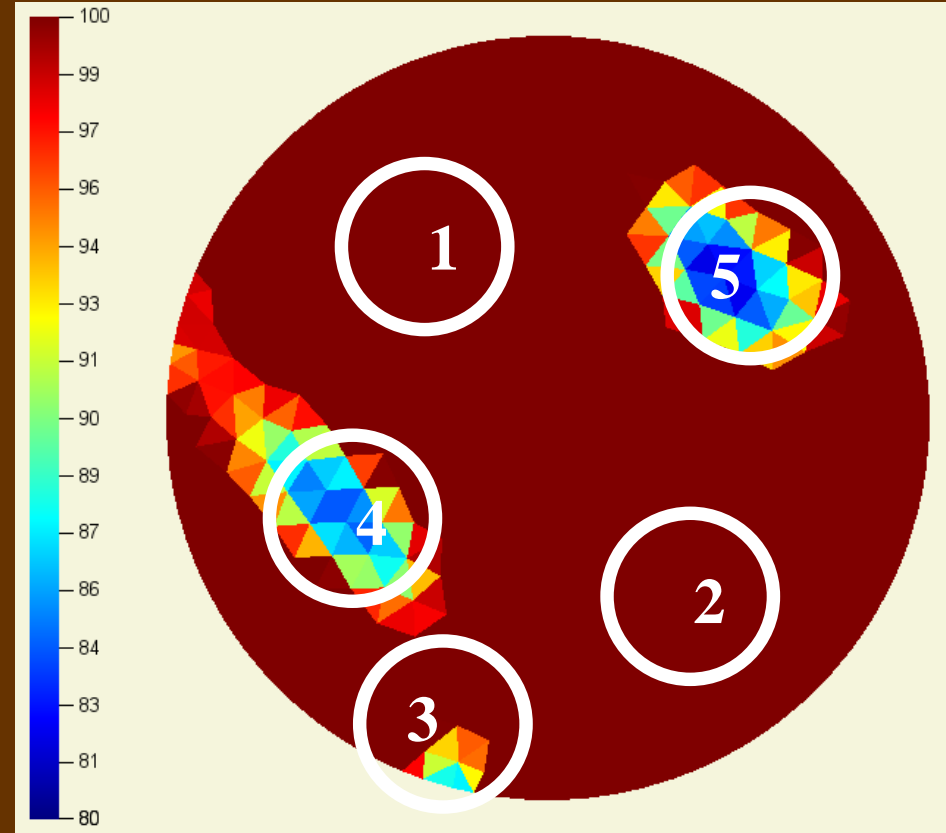
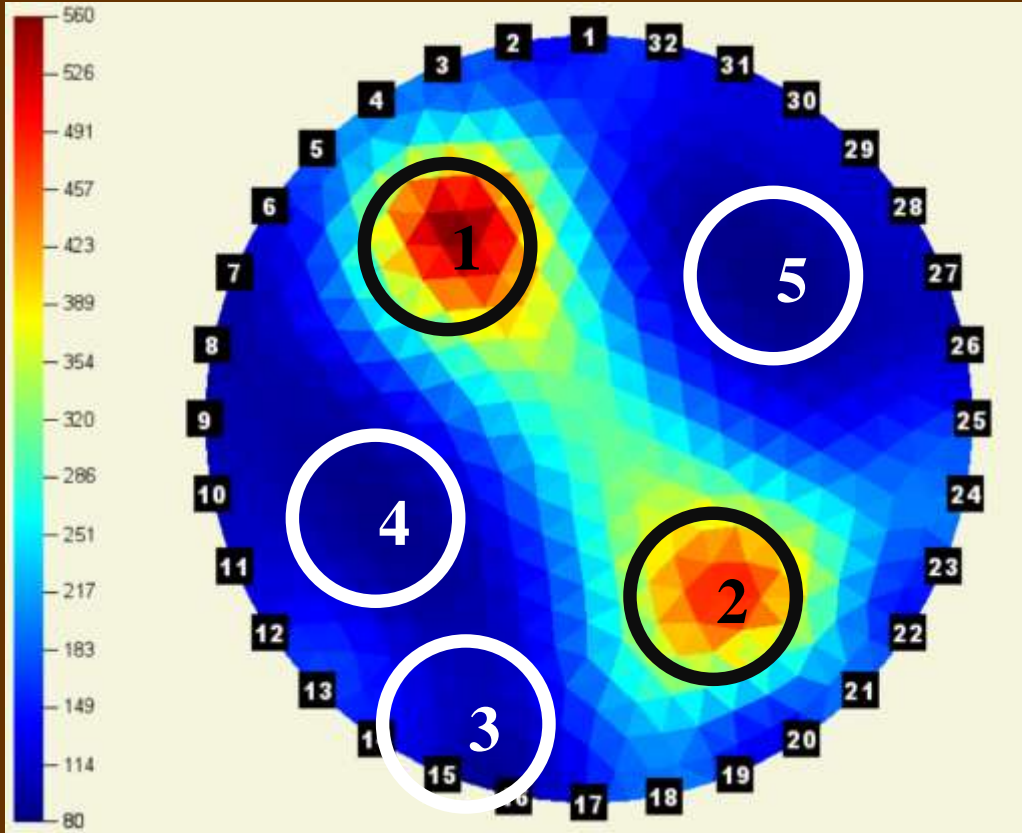




1 am

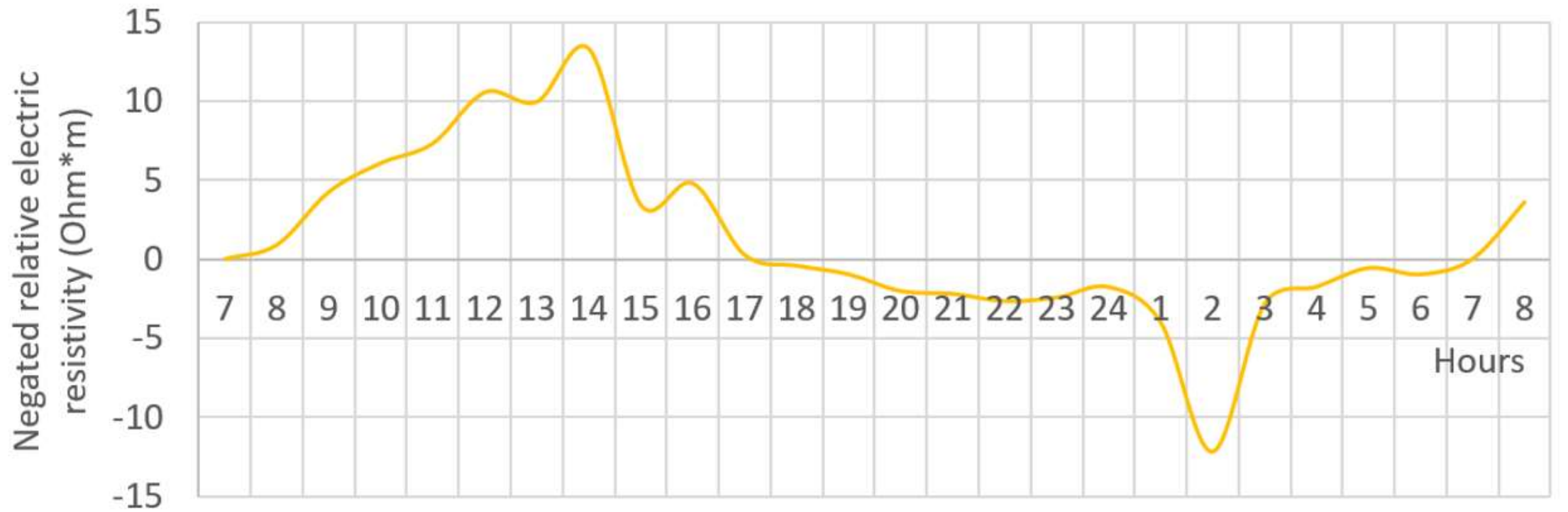


2 am



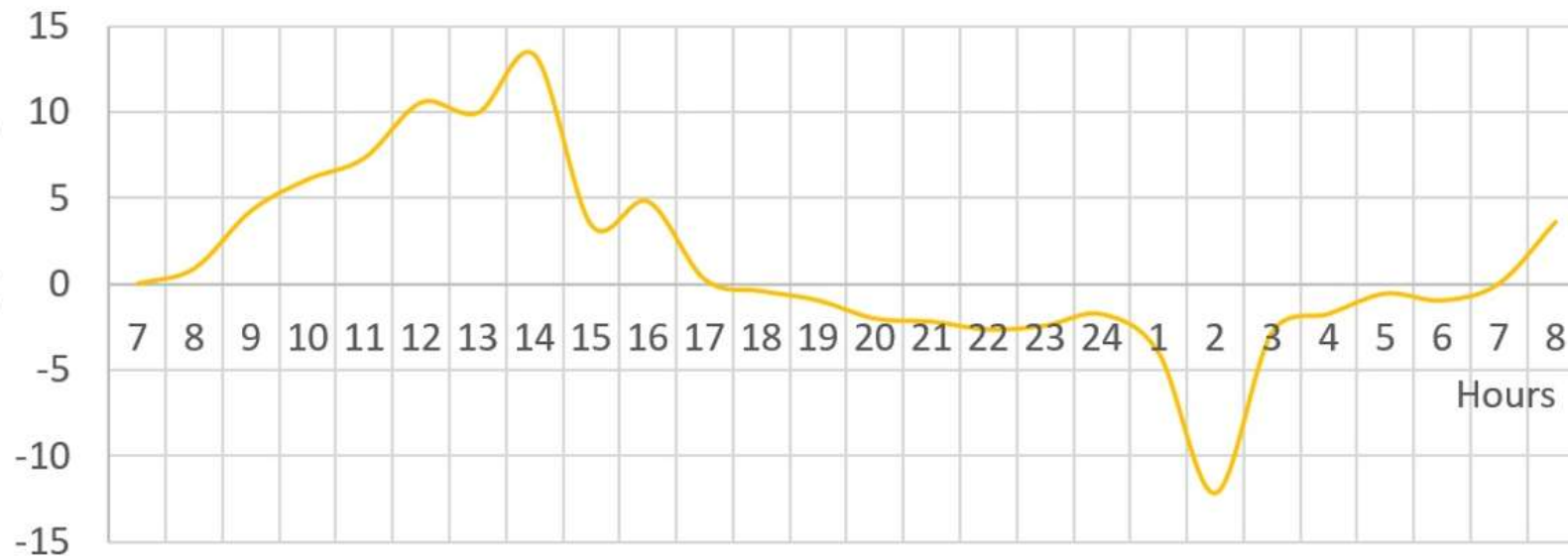
☞ The same 5 area were examined, and the averages were calculated



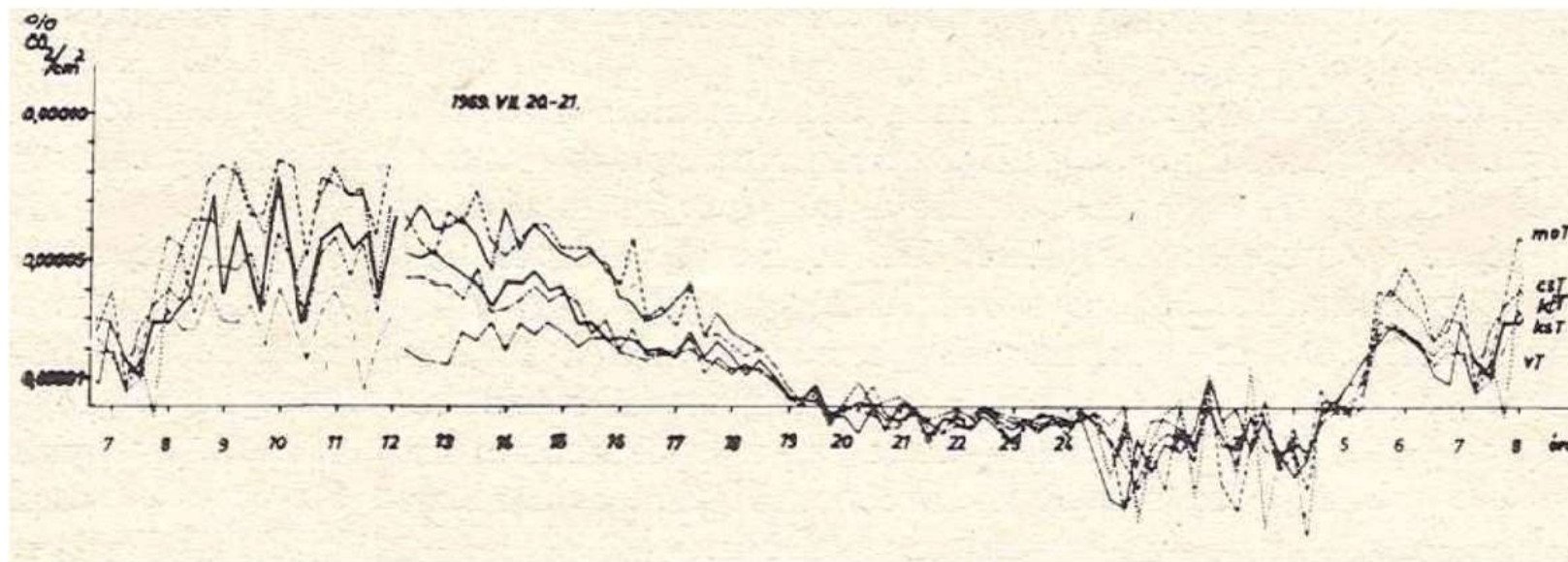


- ⌘ The curve shows the difference of resistivity
- ⌘ The curve was negated to help comparison

Negated relative electric  
resistivity ( $\text{Ohm} \cdot \text{m}$ )



∞ Similarity  
was found





a)

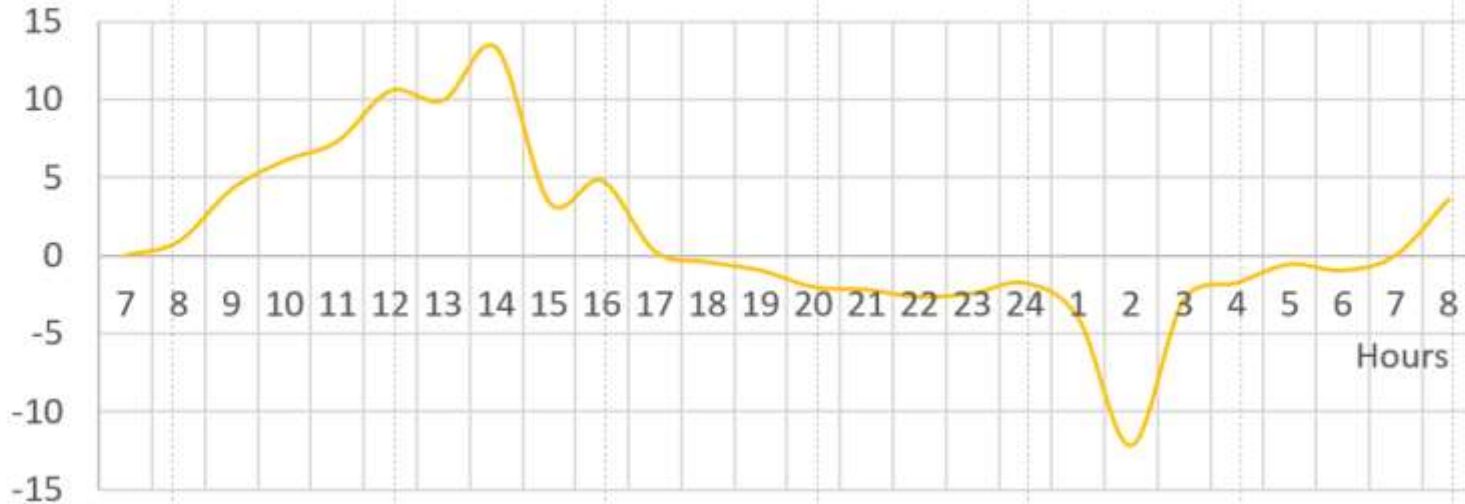
Light intensity

Photovoltaic power (kW)



b)

Negated relative electric resistivity (Ohm\*m)



➤ Similarity was found with light intensity as well

➤ Daily effect wasn't related to not the air's either the wood material's temperature



- The research goes on
- Automatization of measurement was solved by the software team





🌀 Hope to be able to present the new findings soon





Thank you  
for your  
kind  
attention!