

Wood density determination by microwave radar

by

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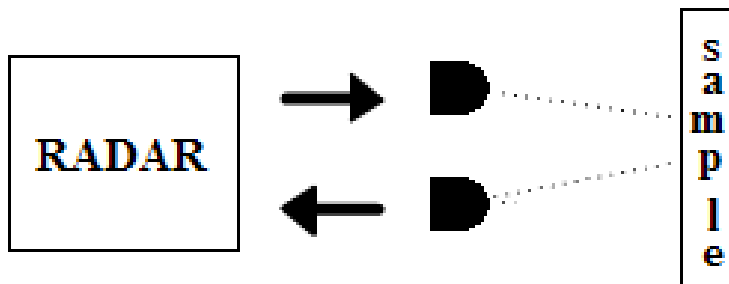
17th International Nondestructive Testing and Evaluation of Wood Symposium,
Sopron, Hungary, September 14-16, 2011.



Samples:

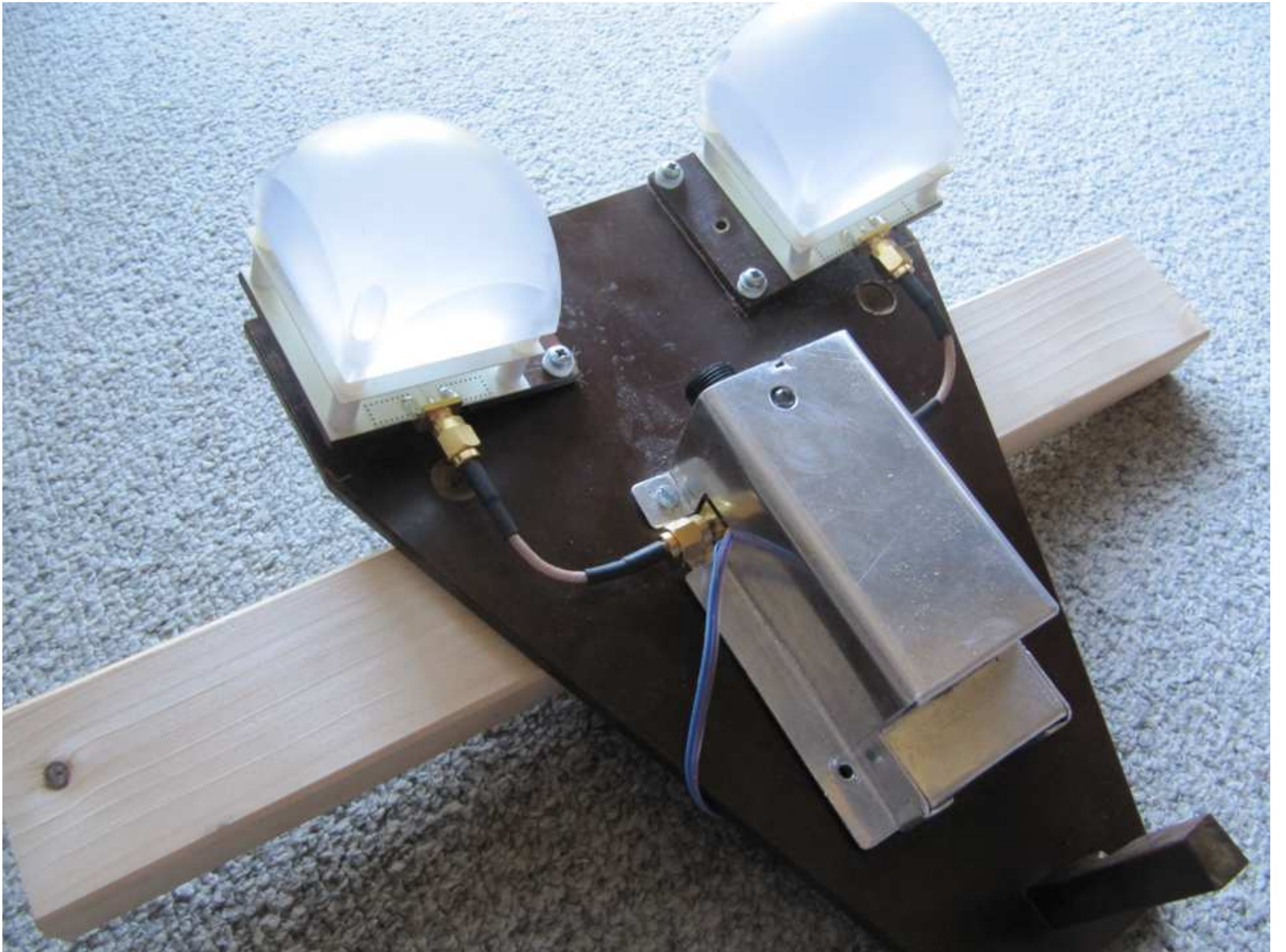
Elm,
Oak,
Silver Birch,
Beech,
Norway spruce,
Scotch pine,

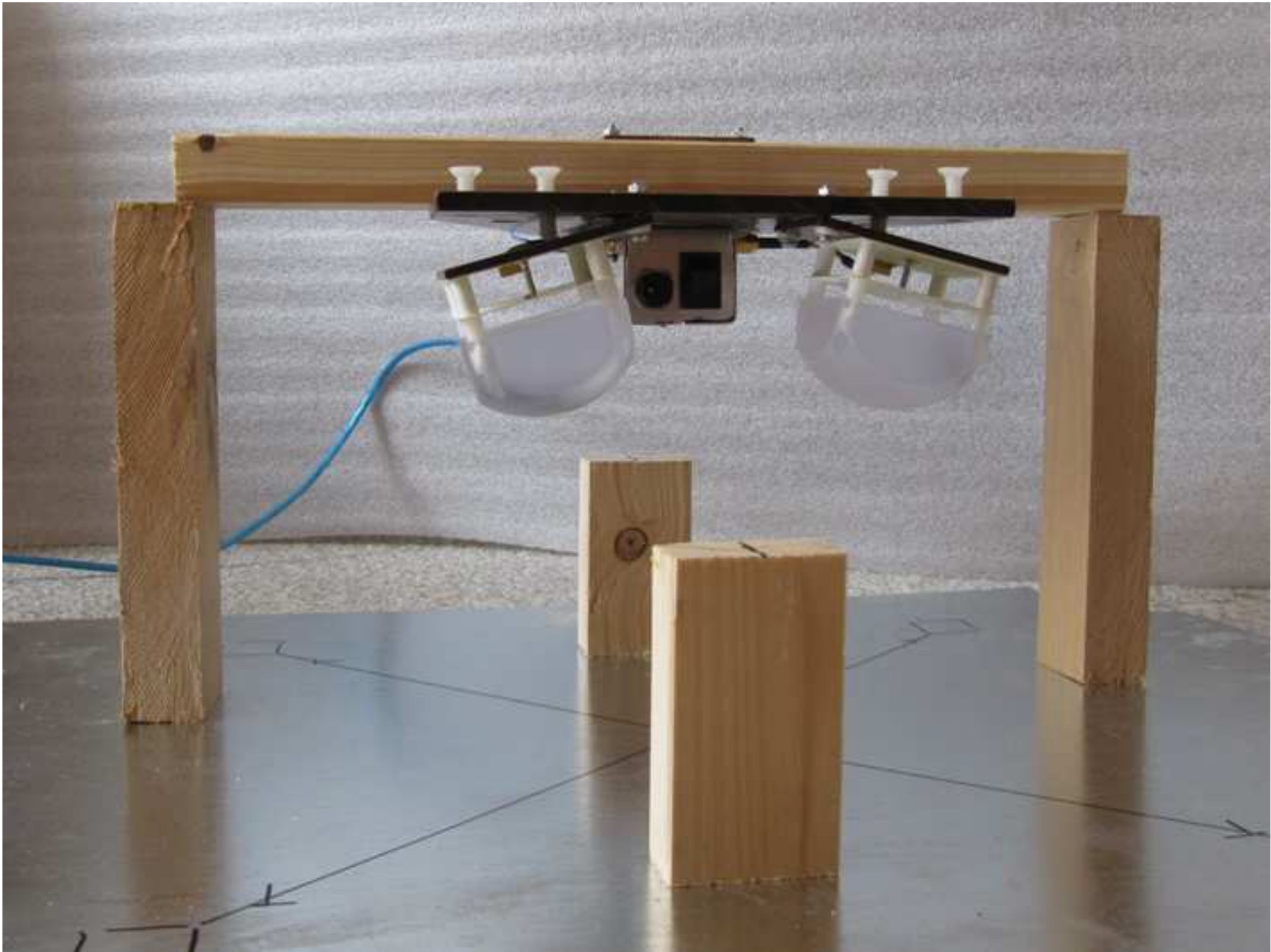
Density at 12% moisture
content covers:
370 – 770 kg/m³ range.
Dimension of the
samples: 25 x 25 x 2 cm.



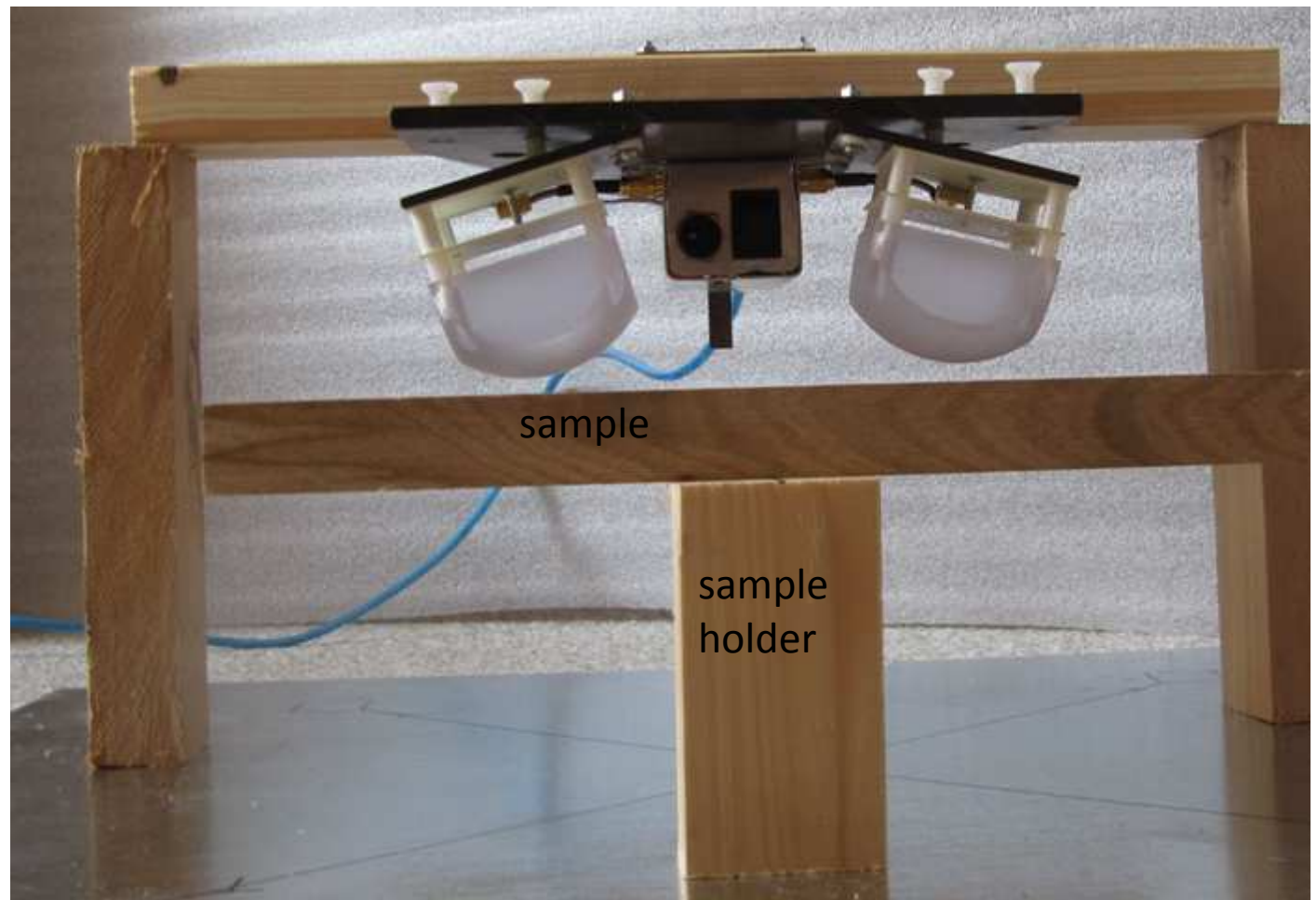
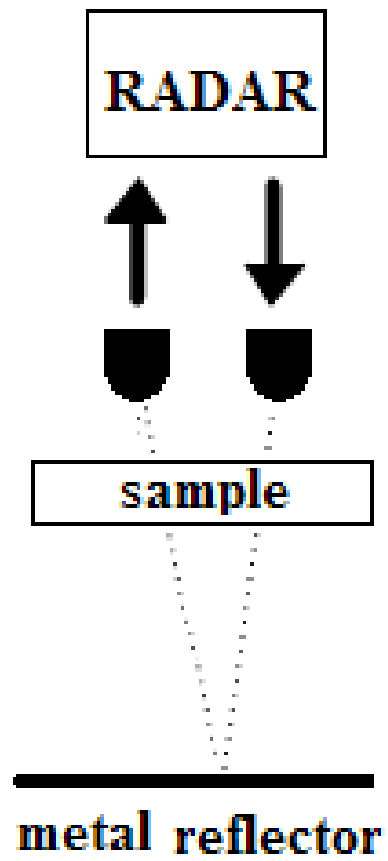
Principle of RADAR technique
(RADio Detection And Ranging)

The applied frequency is 1-6 GHz.
The applied pulse power is in nW range.



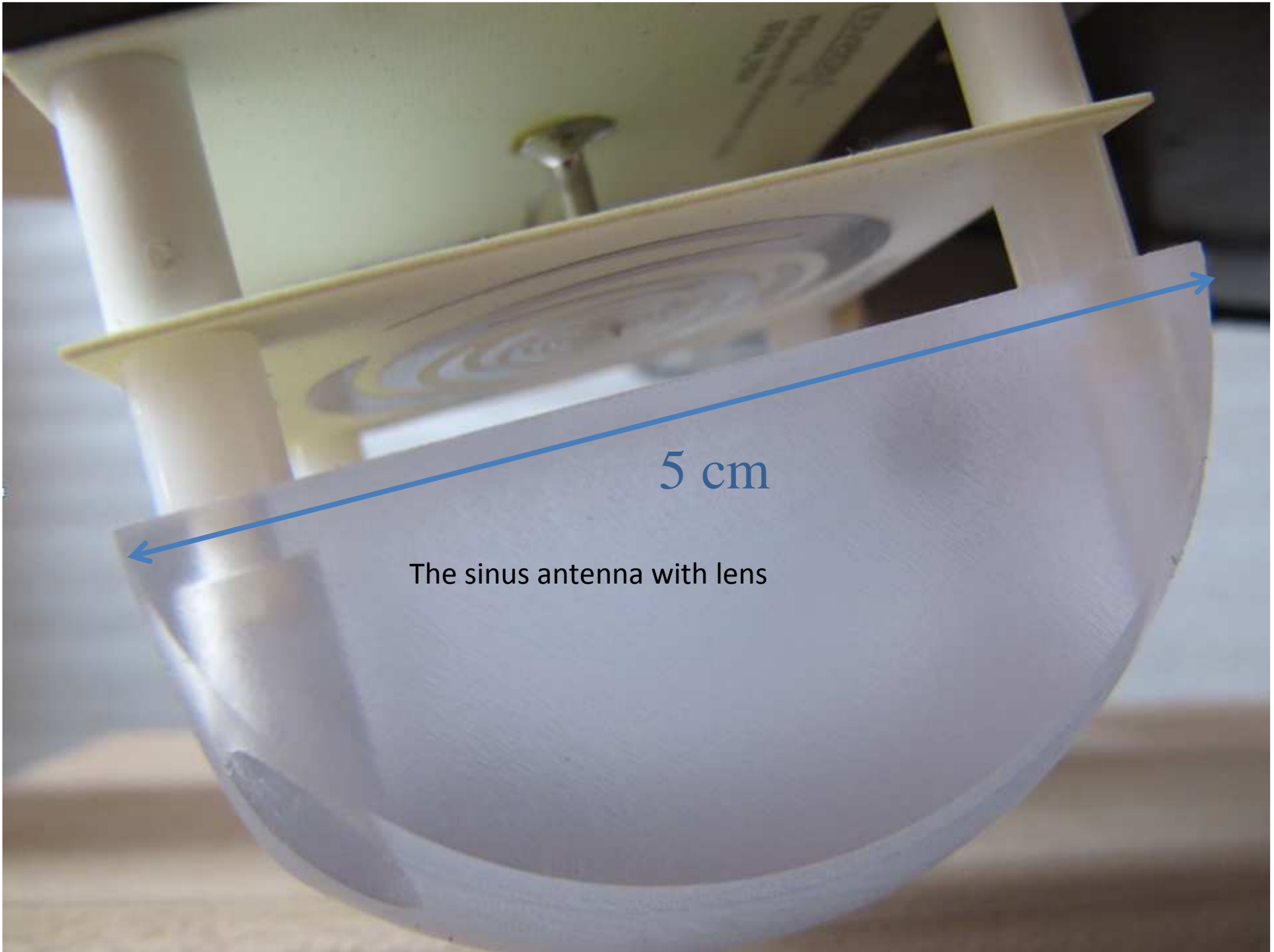








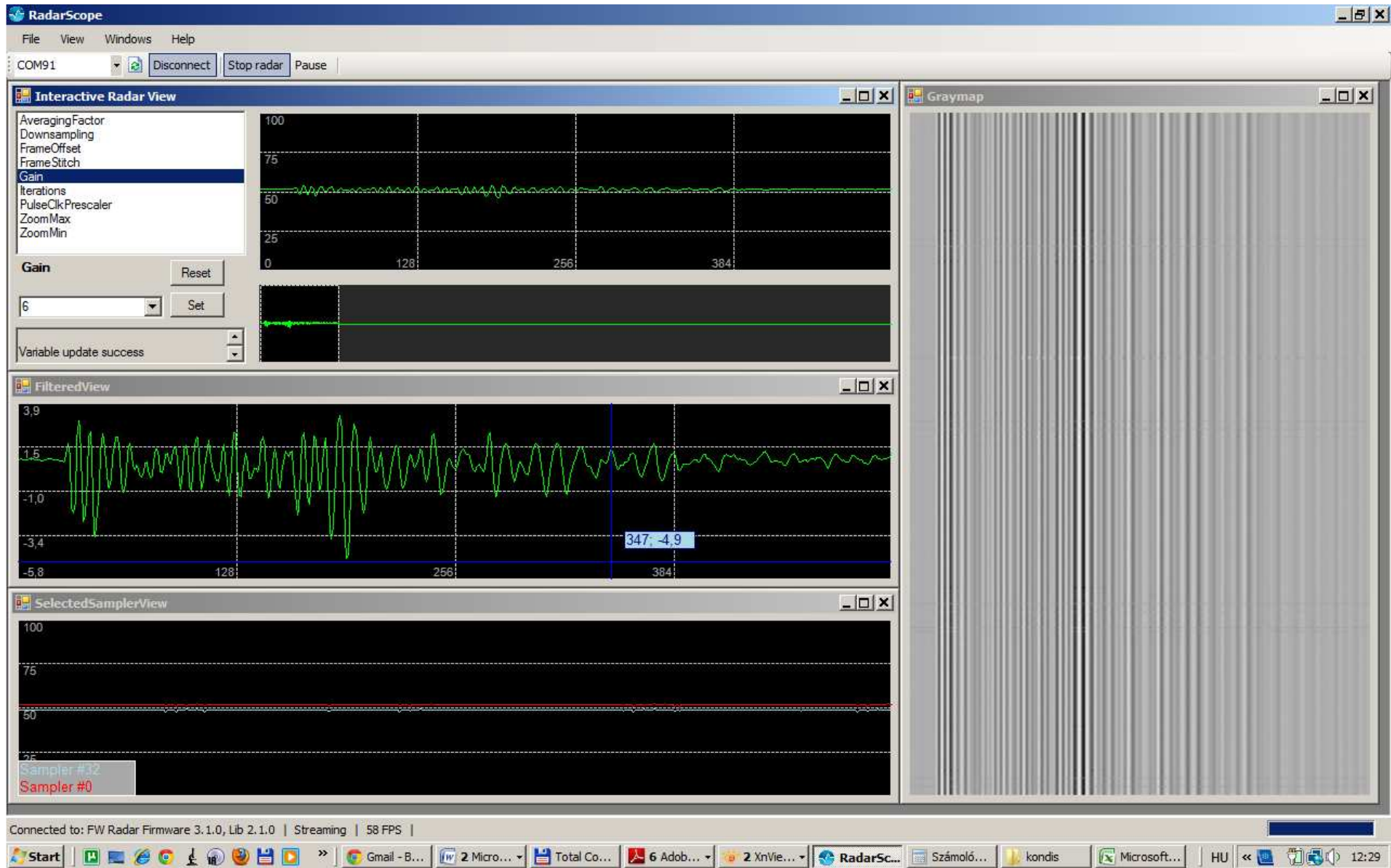




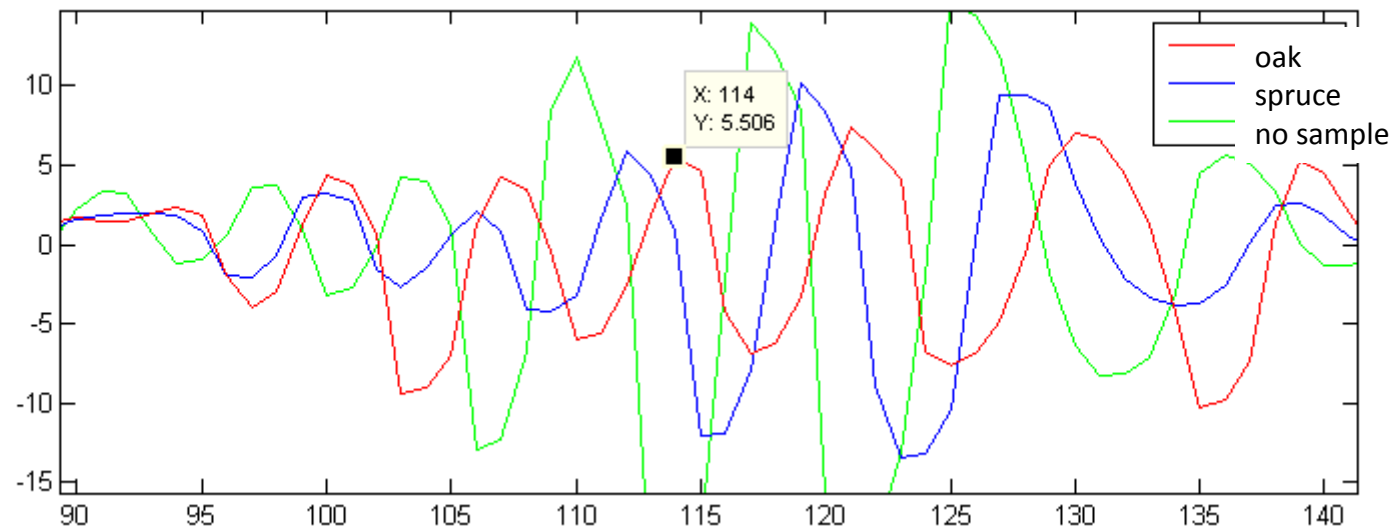
5 cm

The sinus antenna with lens

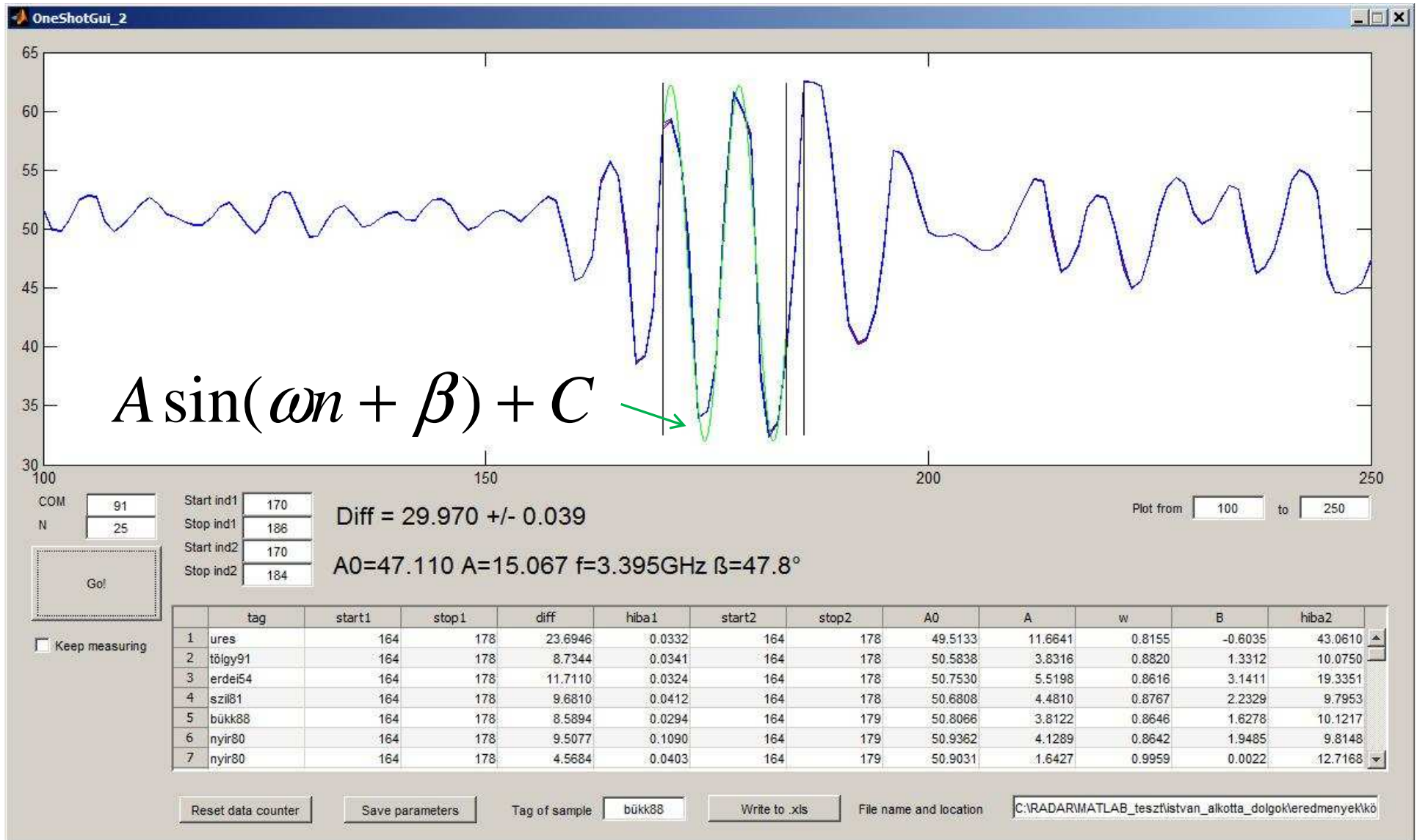
Radar Scope software – part of the development kit

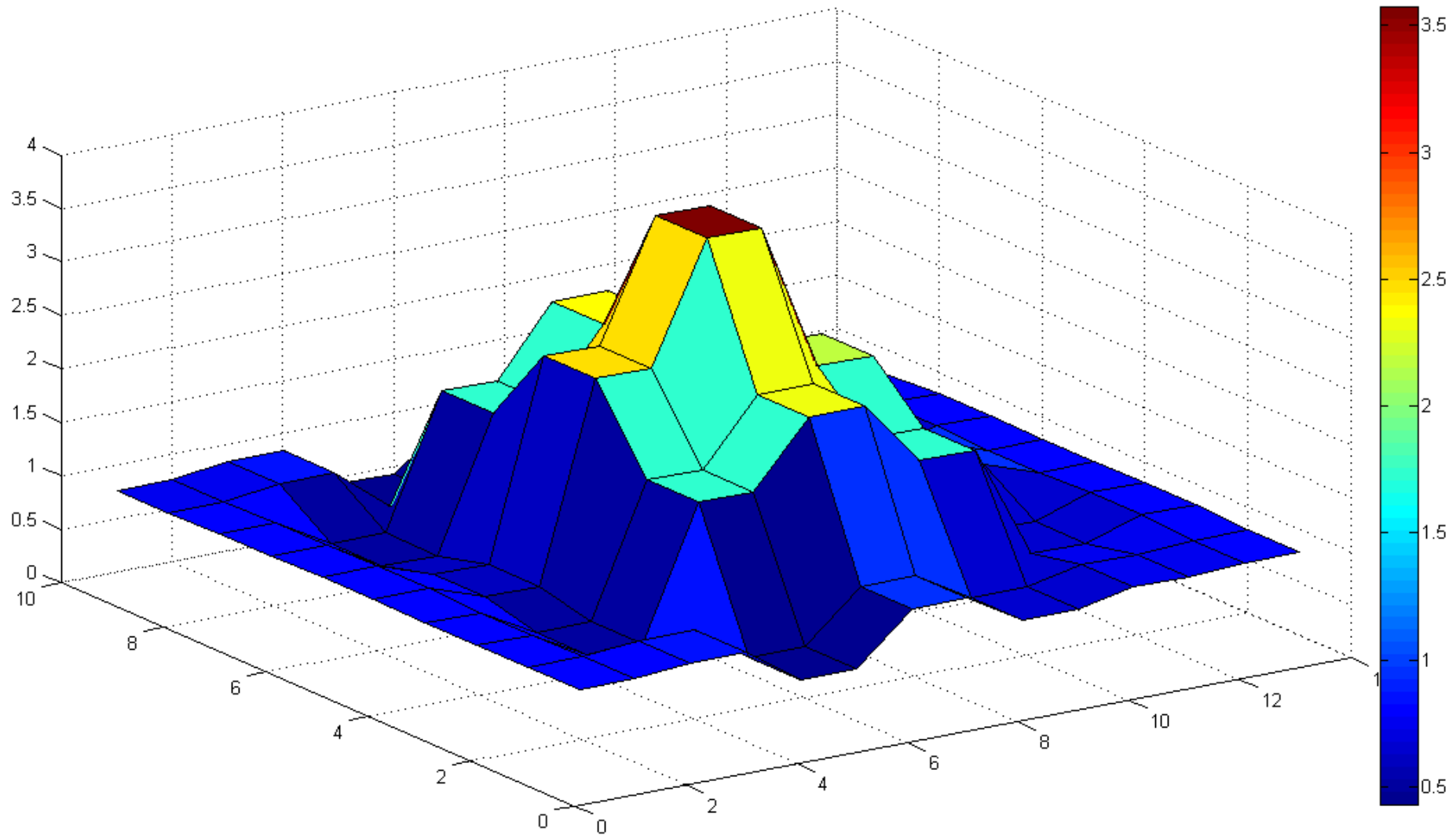


The change of phase angle and amplitude



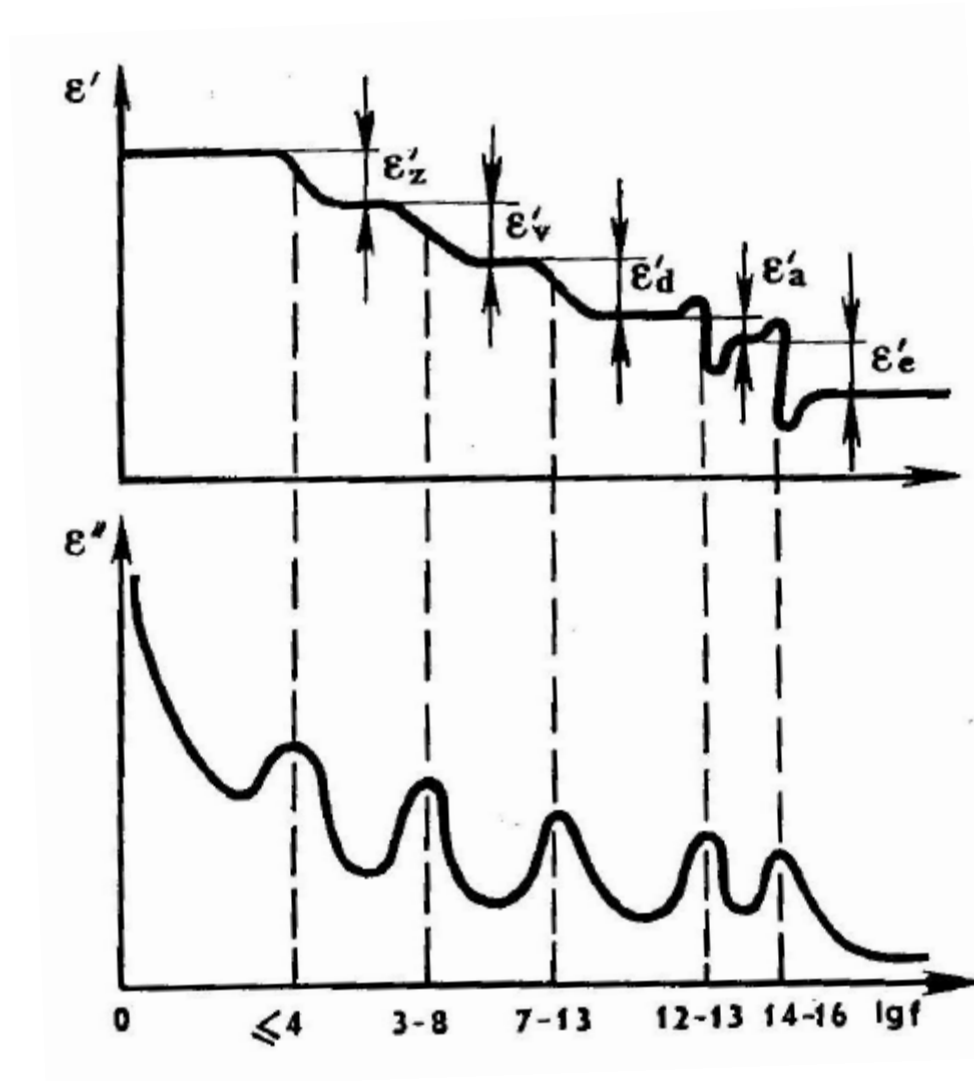
Evaluation of the phase angle and signal amplitude



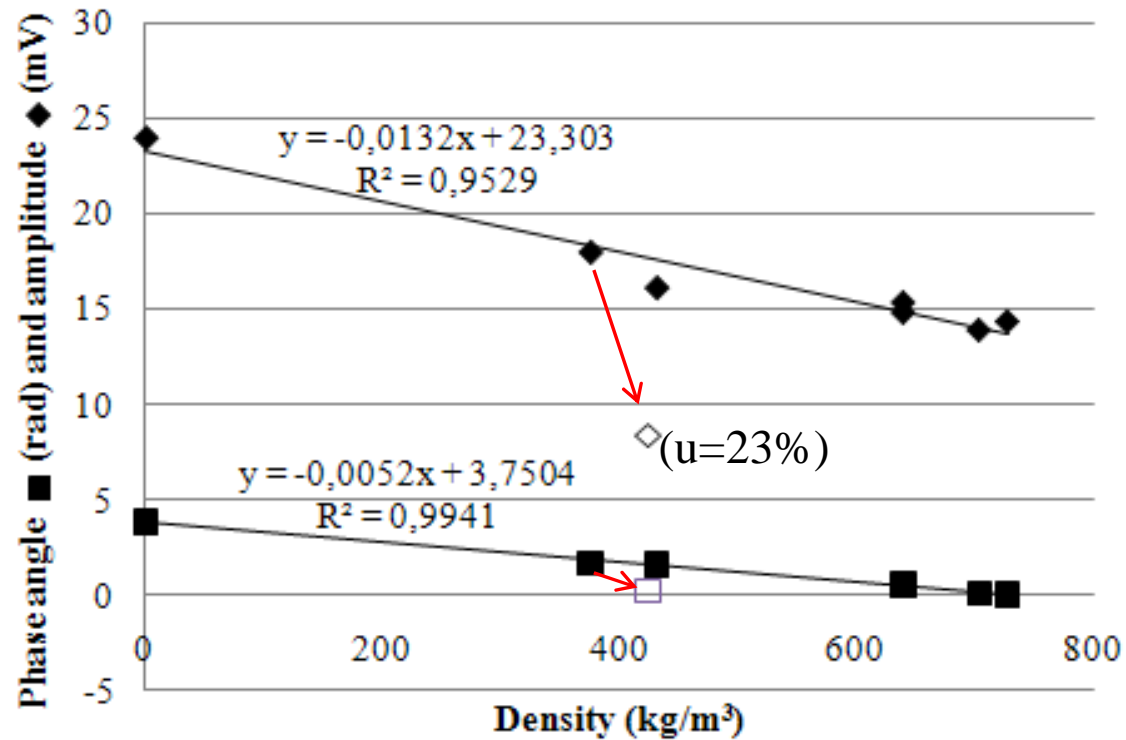


The relative sensitivity of the receiver antenna. Horizontal dimensions are cm, vertical is the received signal amplitude in arbitrary unit.

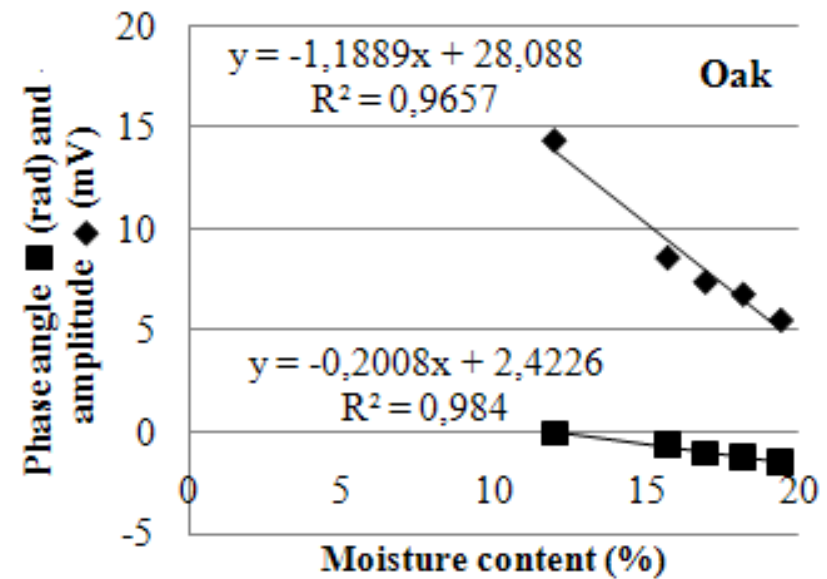
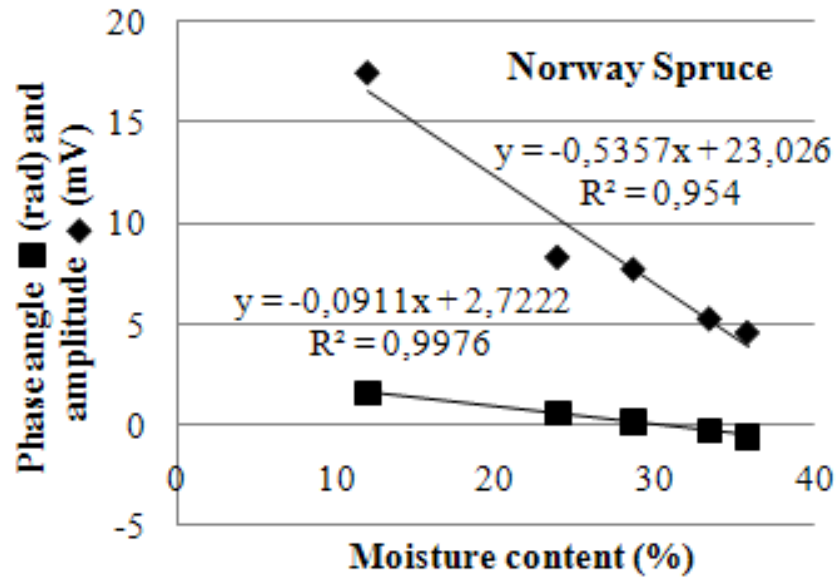
The complex dielectric constant of wood as a function of the frequency (Torgonikov, 1993)



The first test result at u=12% moisture content



Effect of moisture content



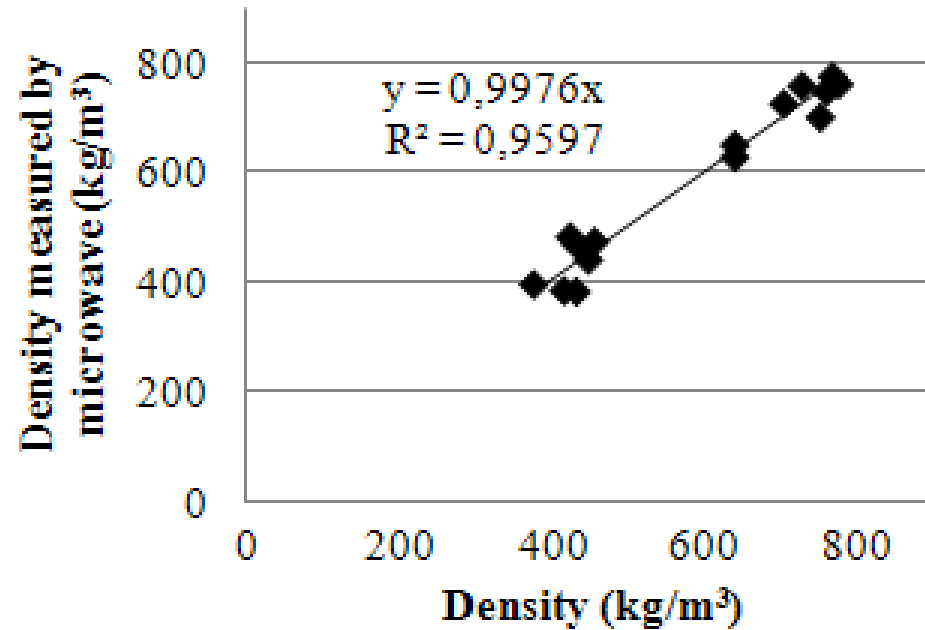
Effect of temperature is not tested, coming soon.

Evaluation and result

$$\rho = \beta c_{11} + A c_{12} + C_1$$

$$u = \beta c_{21} + A c_{22} + C_2$$

Calibration parameter	value +/- standard error
c_{11}	-266,1 +/- 21,1
c_{12}	38,56 +/- 4,23
c_{21}	7,014 +/- 1,562
c_{22}	-2,556 +/- 0,357
C_1	181,6 +/- 45,5
C_2	45,86 +/- 3,28

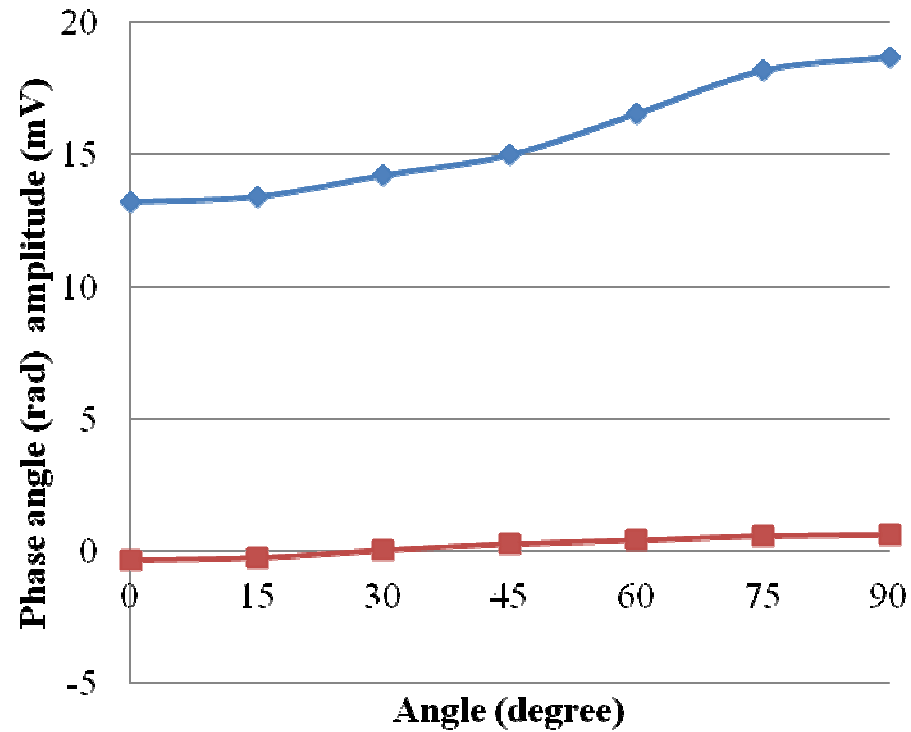


Density range: 370 – 770 kg/m³

Moisture content range: 12 – 36 %



Effect of anatomical orientation



Angle between fiber direction and line between the antennas

CONCLUSIONS

- Microwave radar technique is used for solid wood non contact density determination.
- The setup is a double through transmission, using metal mirror.
- The reflected signal amplitude and phase angle was measured.
- Wood moisture content affects the above mentioned parameters heavily, so simultaneous determination of density and moisture is necessary.
- The standard error of density determination of the presented technique is 35 kg/m^3
- Based on this study microwave radar is applicable for wood density determination.

Thank you for your attention!