Building and validation of a flexible two antenna microwave mammography system

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Outline

- The old system at Mälardalen University
- The new system
- The new antenna
- The breast phantom
- Systems comparison in simulations
- Conclusions

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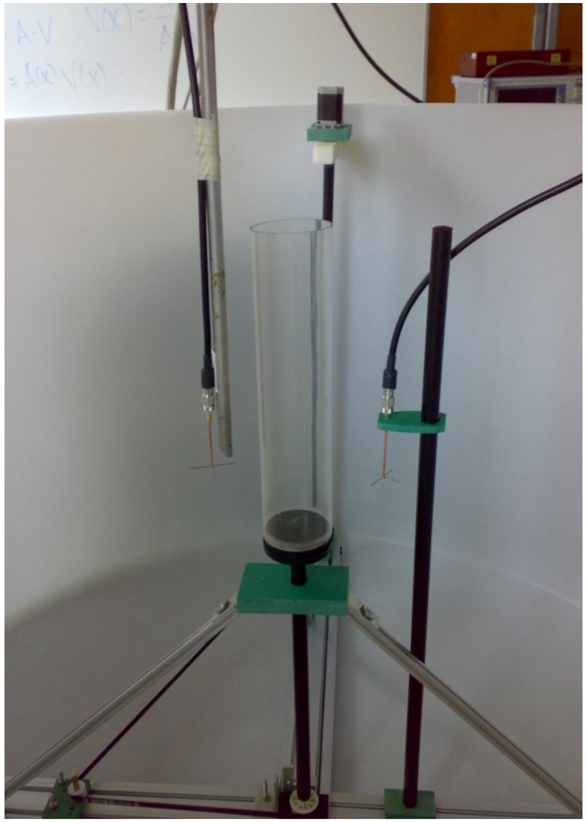
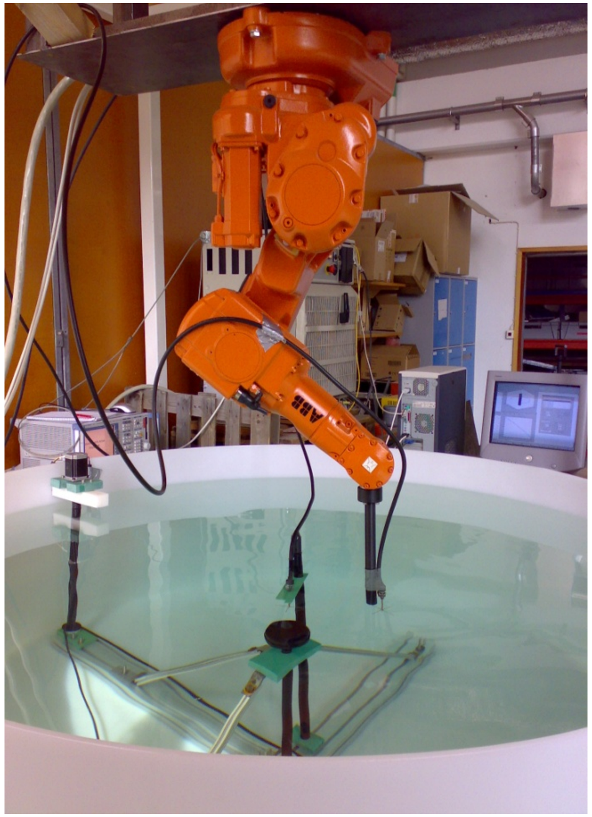
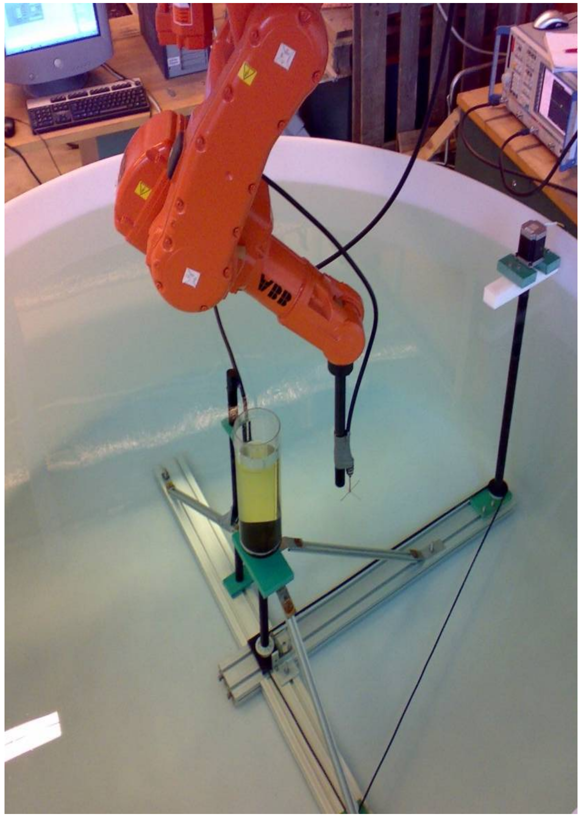
The old system, set-up



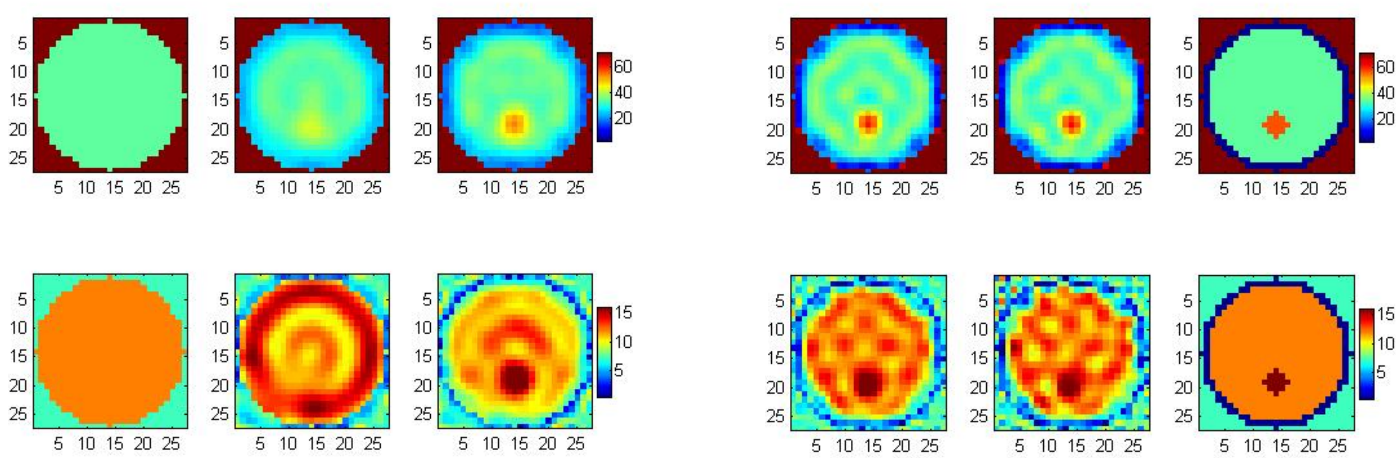




Old system, properties

- Based on ABB-robot – flexible and fast but not suitable for measurements on people. One fixed transmit antenna and one movable receive antenna.
- Simple monopole antennas immersed in water and reasonably matched at frequencies from 0.9-1.5 GHz.
- The monopole is easy to model but has a strong non-radiating near field which means loss of received power and sensitivity to objects in it's surroundings. Omnidirectional radiation properties means loss of power in the wanted direction.
- The system used water as the coupling medium which limits the usabiliy for higher frequencies approaching 2-3 GHz.

Old system, reconstructions

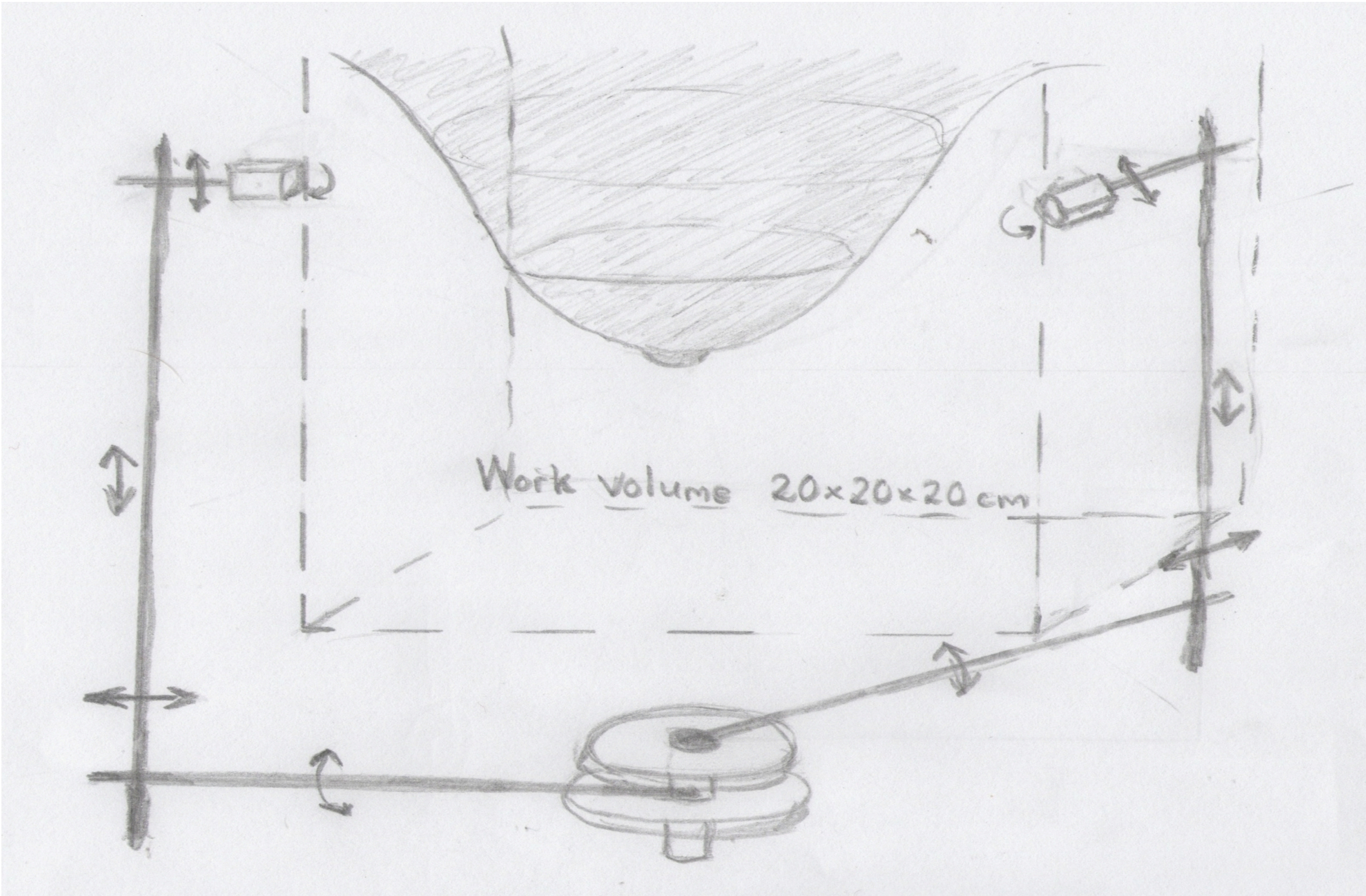


Reconstructions of a 2D breast phantom with the Supélec algorithm based on measurement data from the old system.

New system, idea

- Able to measure on real breasts.
- Flexible two antenna system with movable transmit and receive antennas.
- It should be possible to place the antennas in any position on the breast.
- Possible to measure two orthogonal polarizations.
- No coupling medium surrounding the system and therefore the antennas should be placed directly on the breast.
- Laser scanning gives the geometry of the measured breast and the position of the antennas.

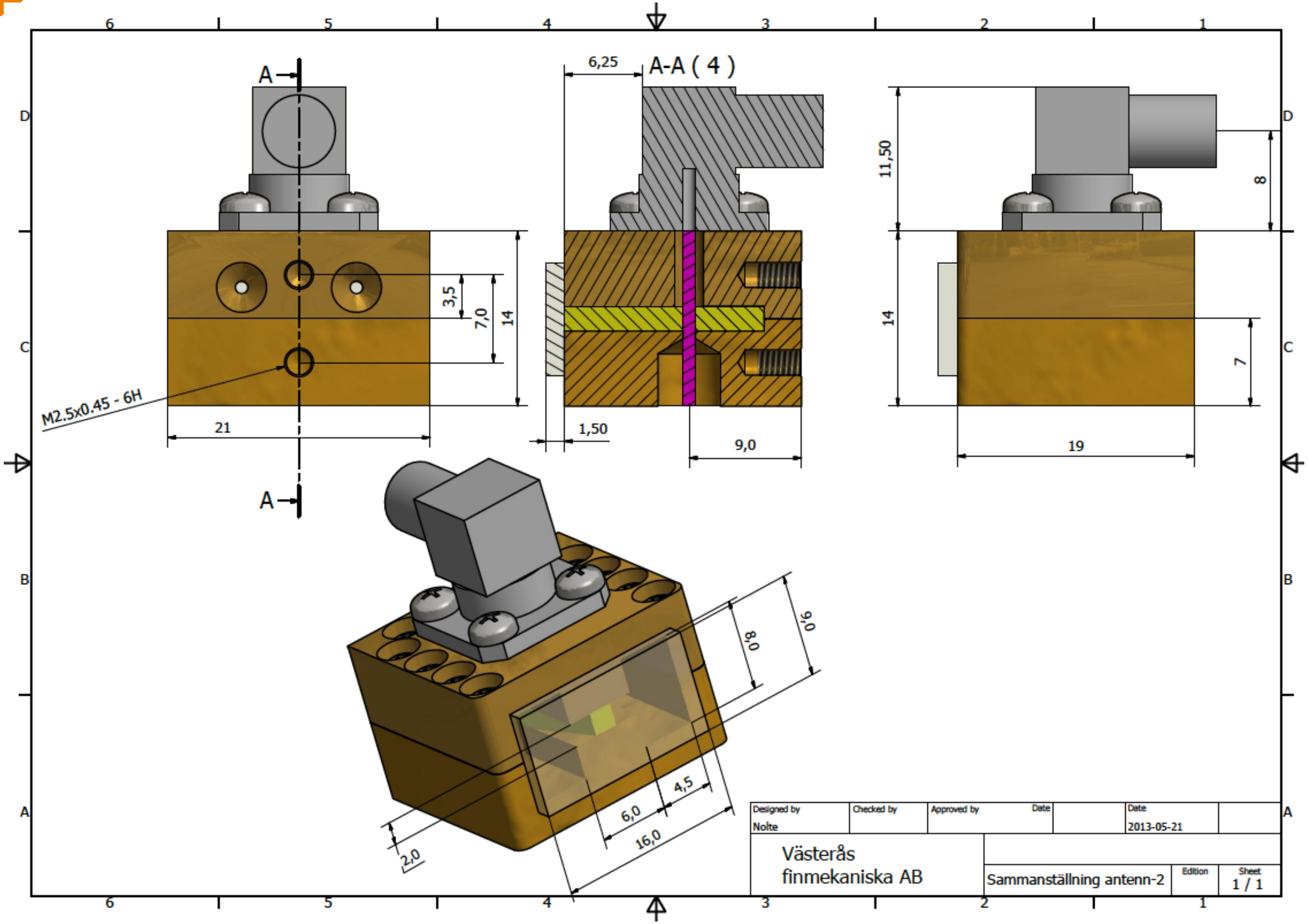
The new system, set-up (sorry for my bad handwriting)



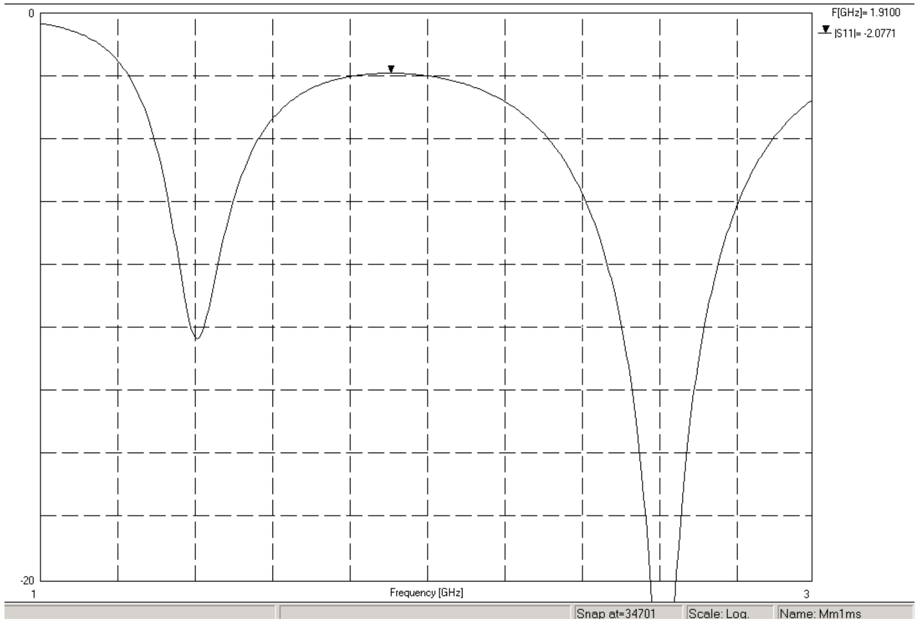
The new antenna, demands

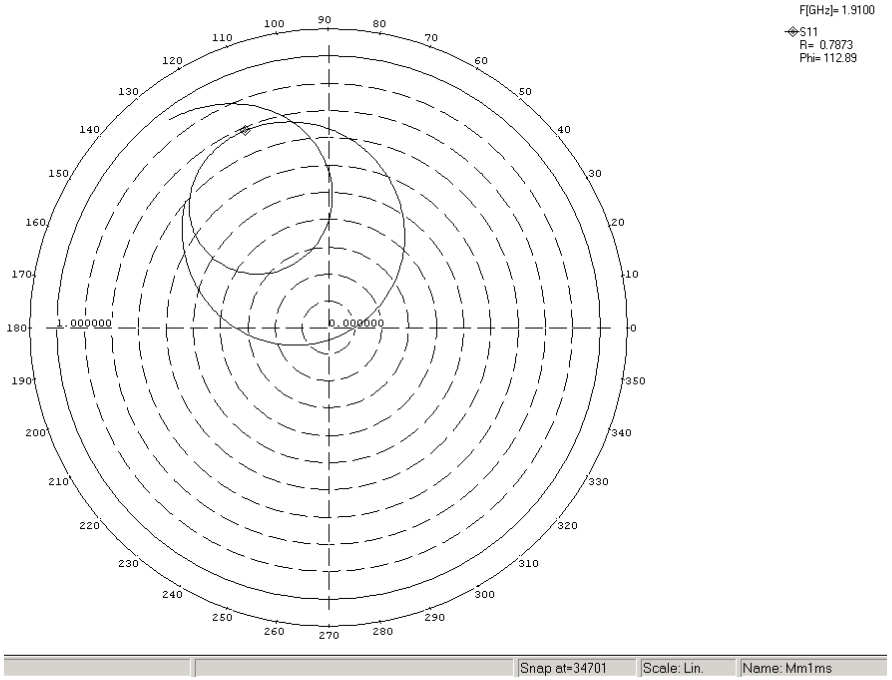
- Directive radiation pattern.
- Small reactive near field.
- Broadbanded with reasonable matching to 50 ohm from 1 GHz to 3 GHz.
- Surpression of surface waves (Zenneck waves) that can propagate directly from transmit to receive antenna without passing through the breast.
- Well defined polarization.
- Small compared to the breast.
- No sharp edges.

The new antenna, design



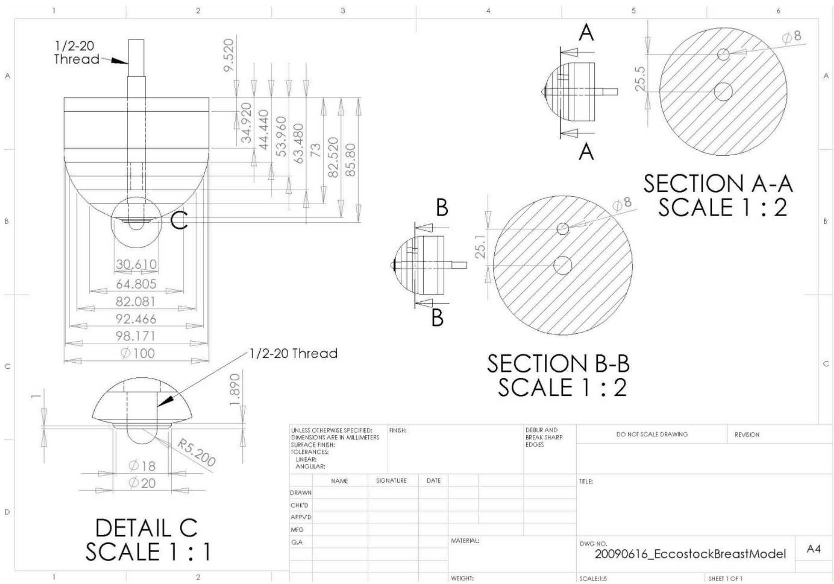
The new antenna, simulations, S11

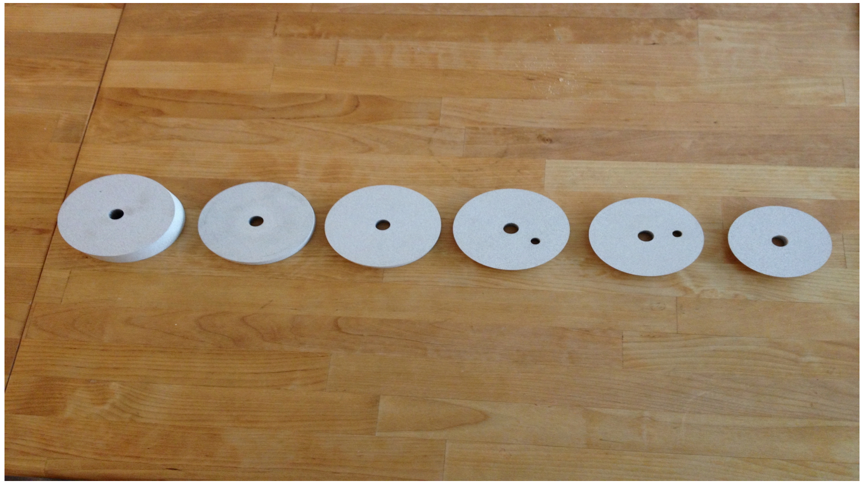




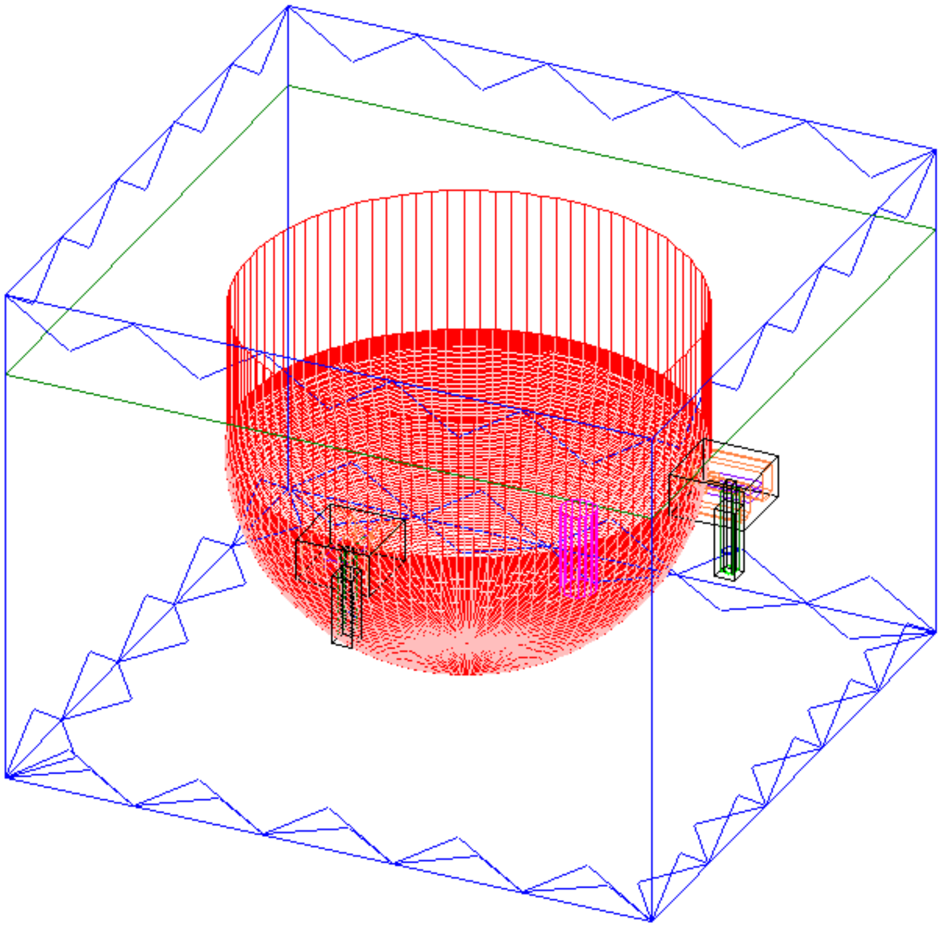
Clearly two matched frequency bands and an area around 2 GHz not well matched inbetween. The antenna impedance is a bit to low today but will be changed in later versions to give good matching in one frequency band from 1 to 3 GHz. To obtain better dynamics around 2 GHz an amplifier could be used.

The phantom, same type as Calgary University, Eccostock HiK=25





Antenna simulations, radiation set-up



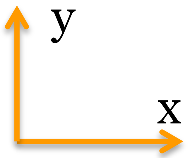
Breast phantom made from Eccostock HiK=25 material with tumour (magenta) of 8 mm diameter and 20 mm length.

Breast has dielectric properties eps=25, sigma=0.0034.

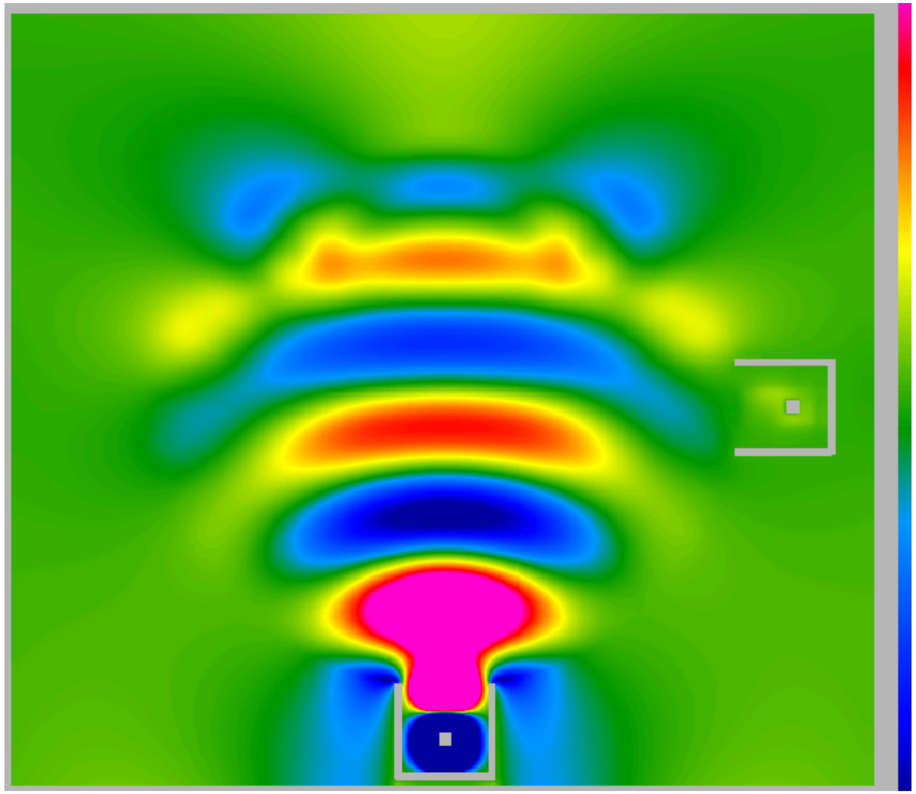
Tumour has dielectric properties eps=20, sigma=1.3.

Two antennas placed 90 degrees apart on the cylindrical part of the phantom. The tumour is further down. Breast slightly compressed for good contact.

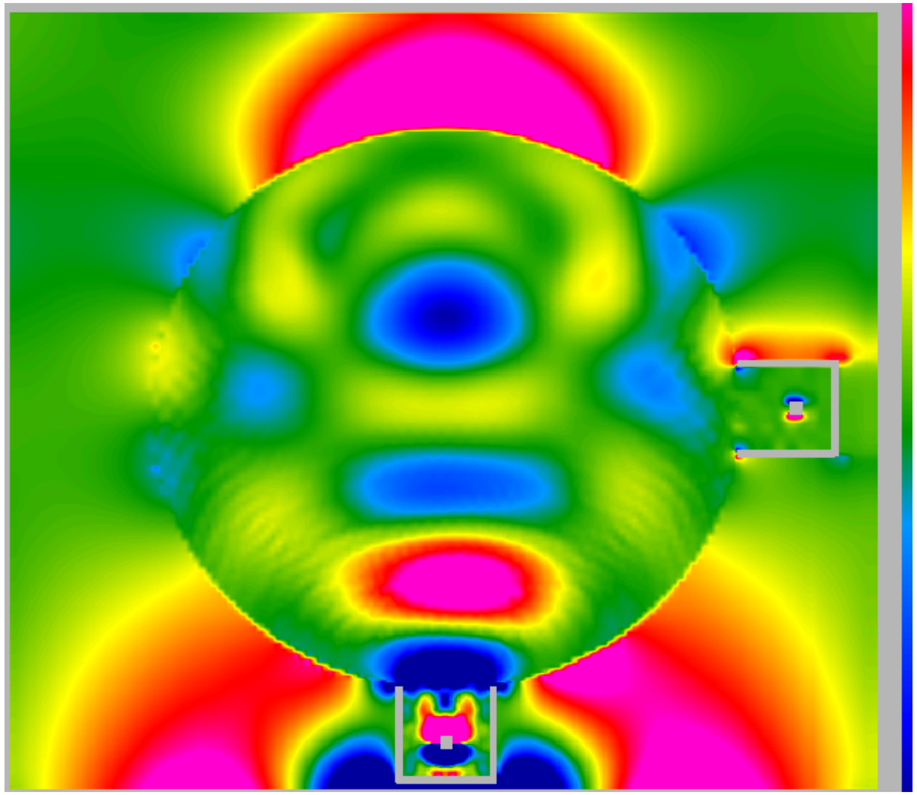
Antenna simulations, Ez and Ey fields at 2 GHz



Ez

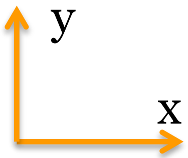


Ey

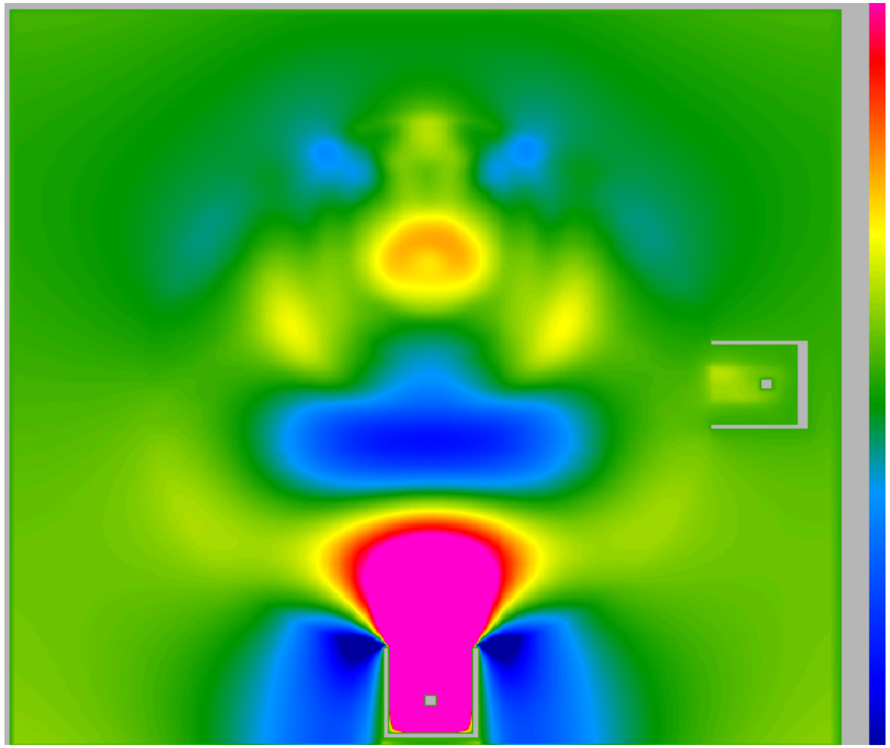


Note that the amplitude scale is set 10 times larger for the Ez fields than for the Ey fields.

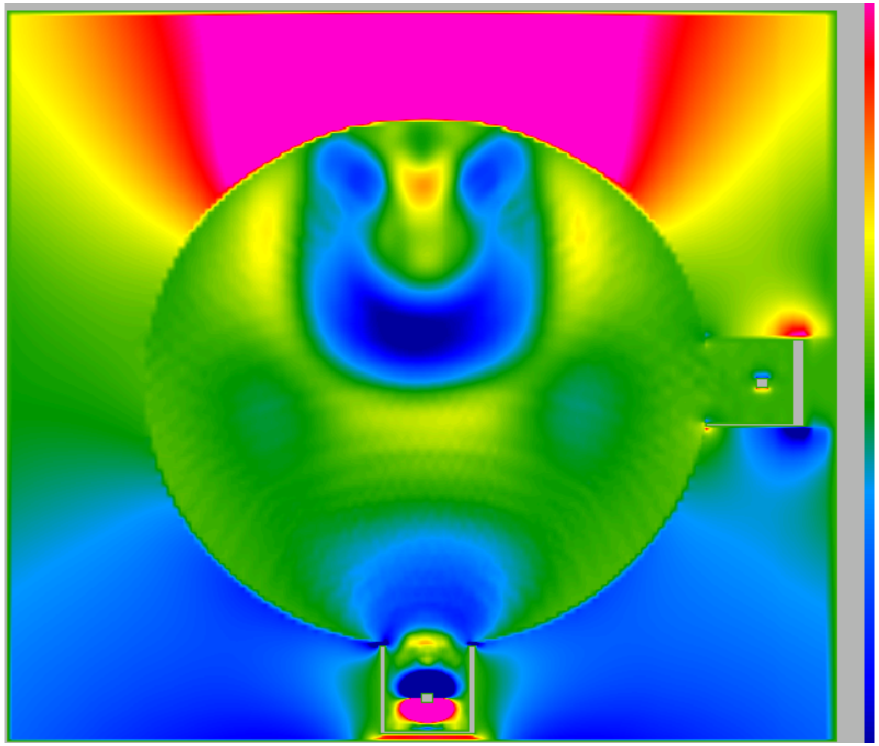
Antenna simulations, Ez and Ey fields at 1.2 GHz



Ez

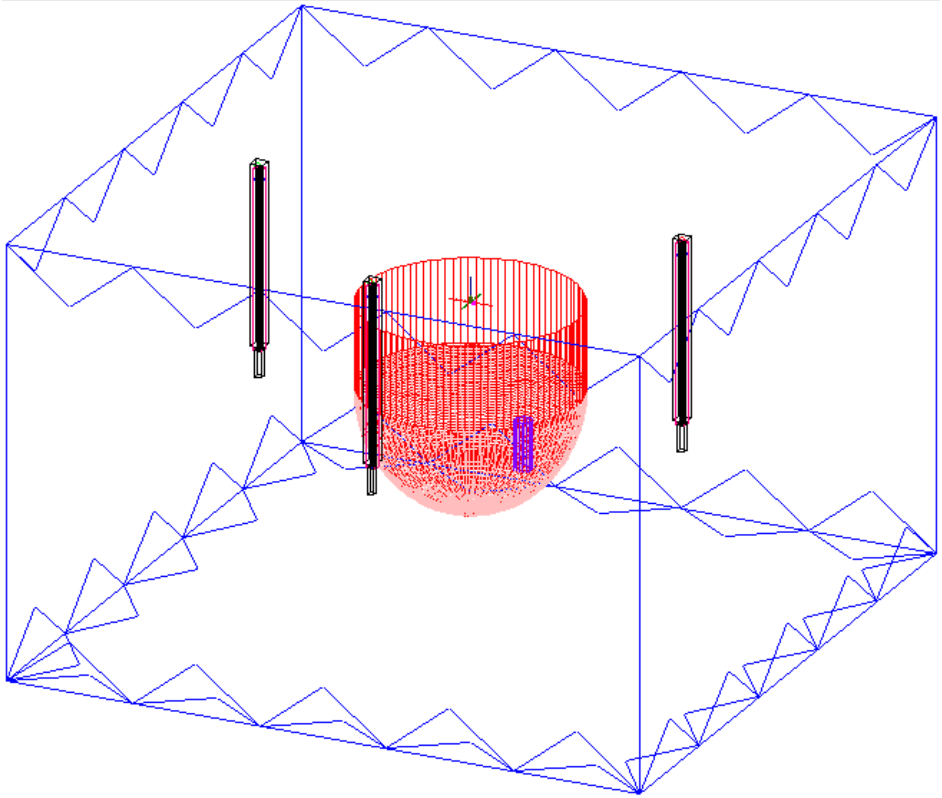


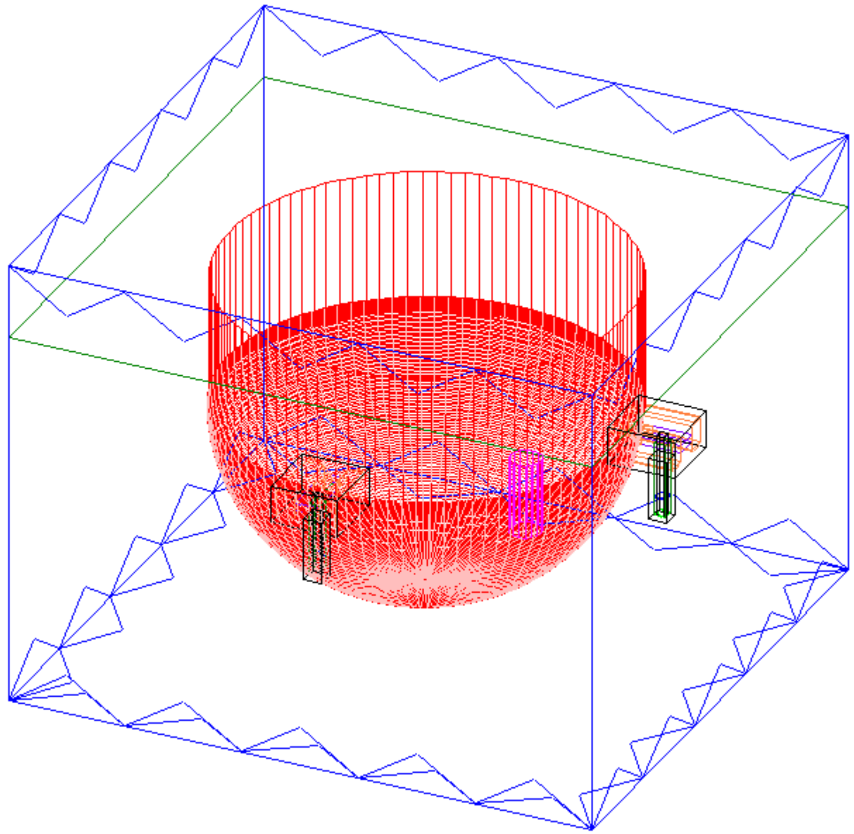
Ey



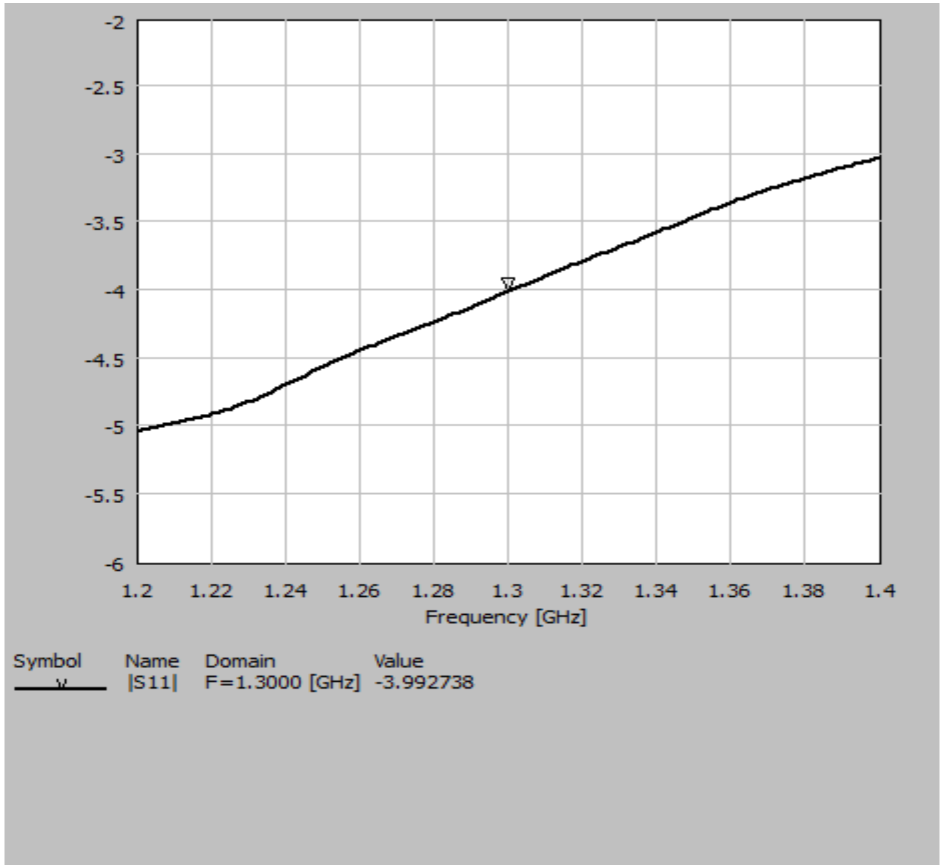
Note that the amplitude scale is set 5 times larger for the Ez fields than for the Ey fields.

Comparison, old system vs new system, setup

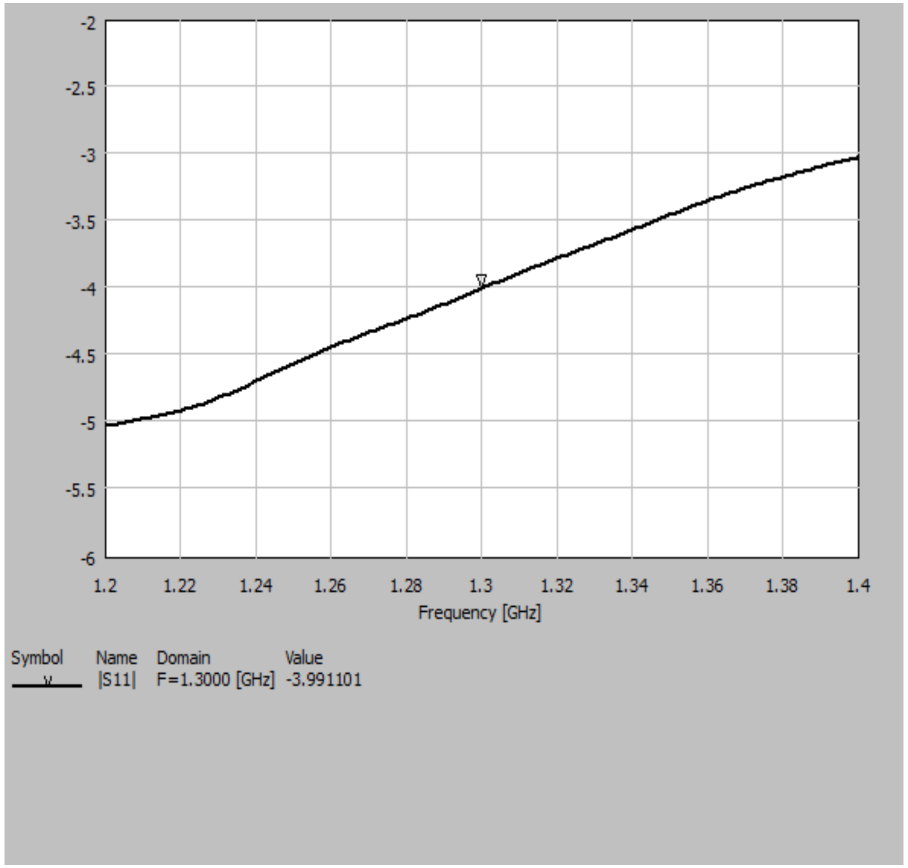




Comparison cont, S11 of old antenna at 1.3 GHz

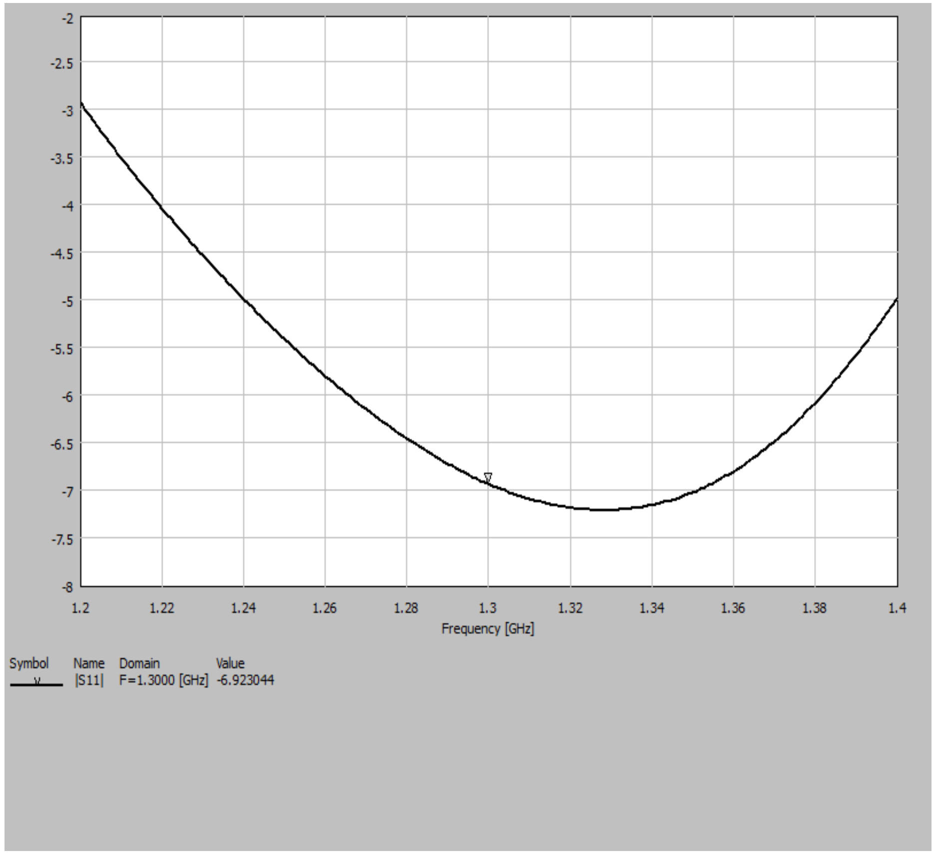


Without the tumour

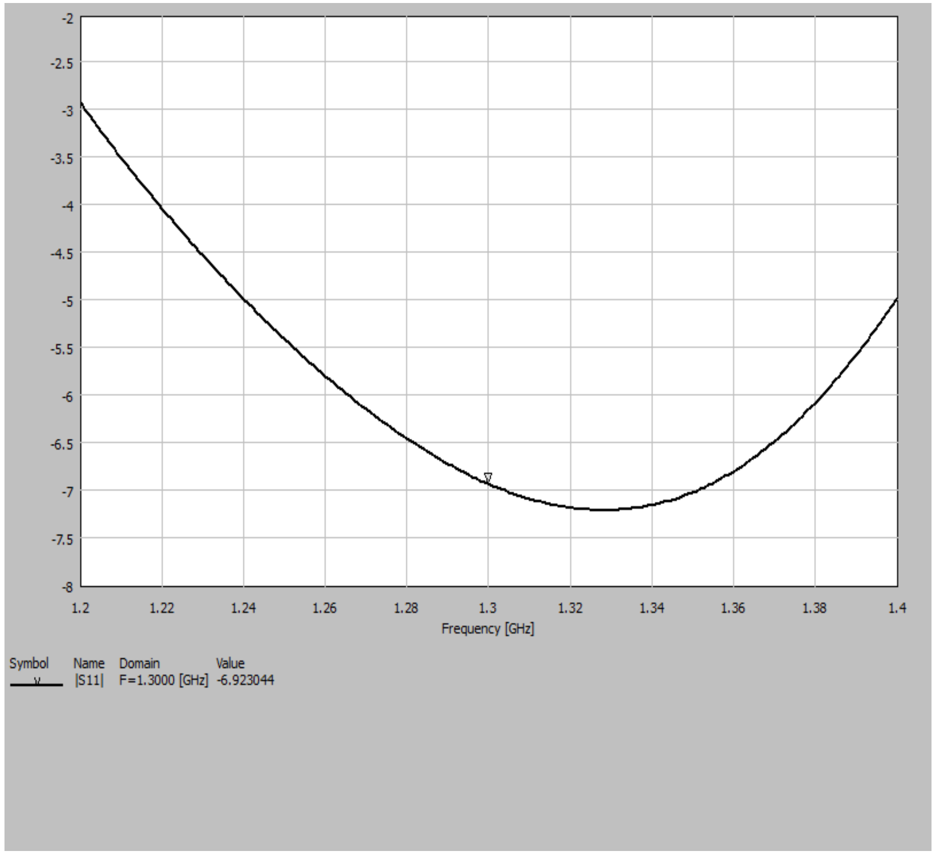


With the tumour

Comparison cont, S11 of new antenna at 1.3 GHz

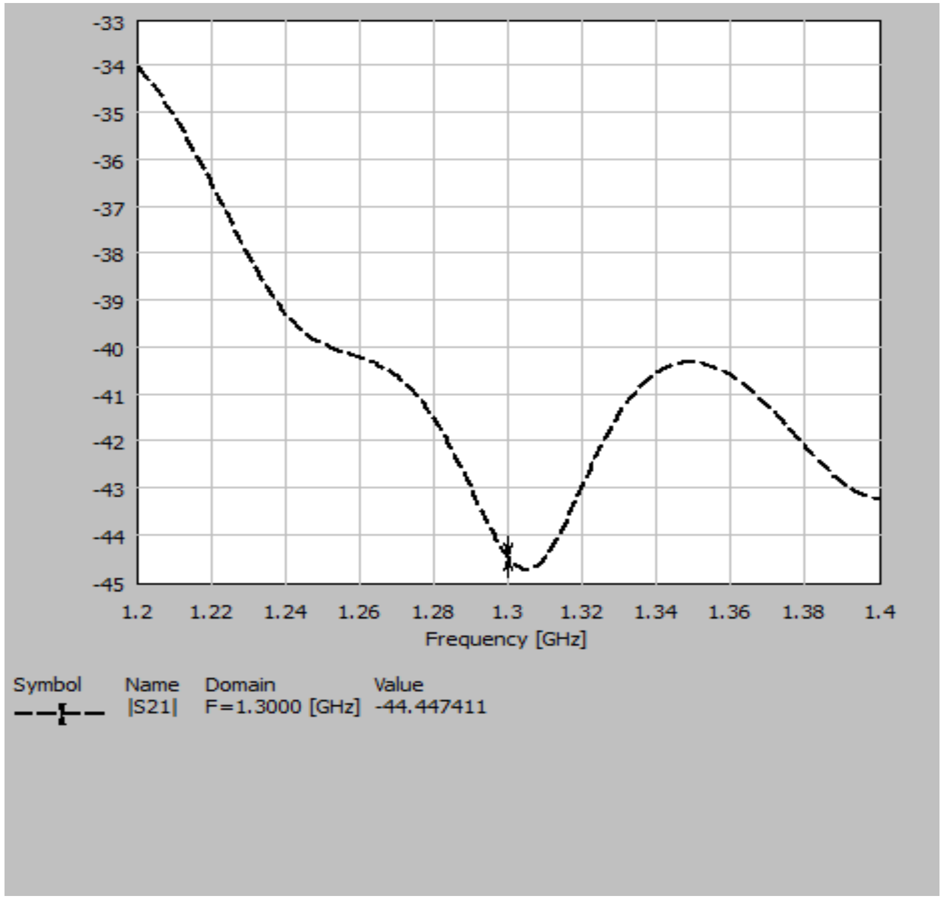


Without the tumour

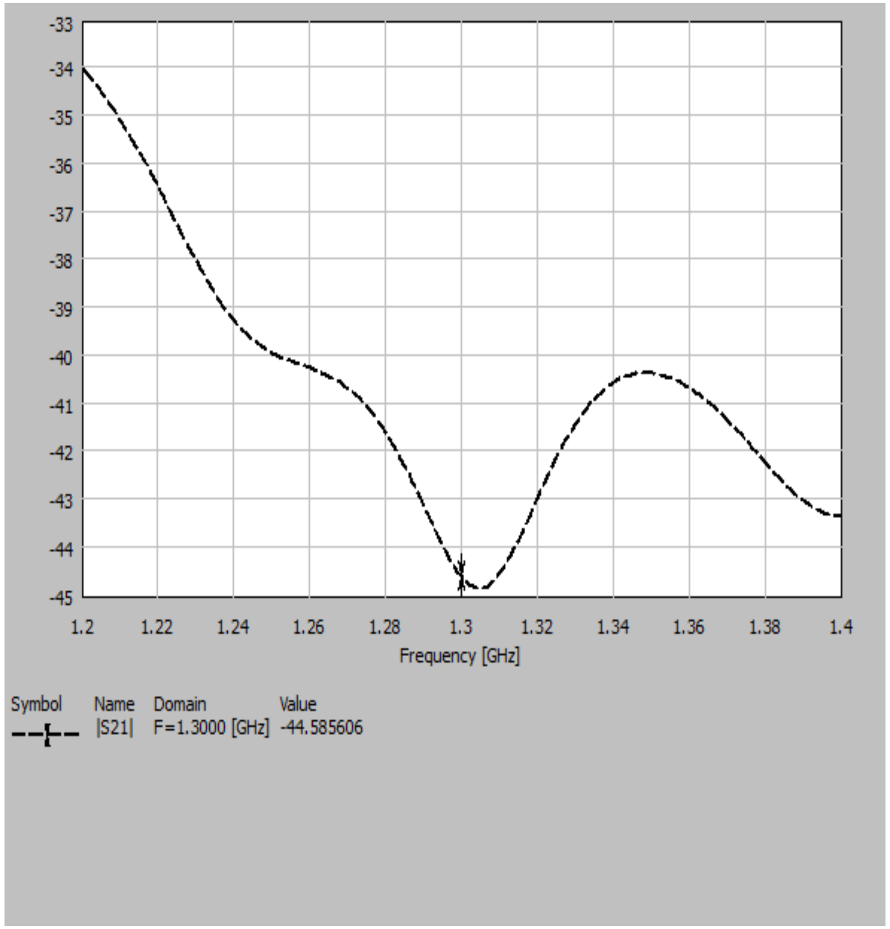


With the tumour

Comparison cont, S21 of old system at 1.3 GHz

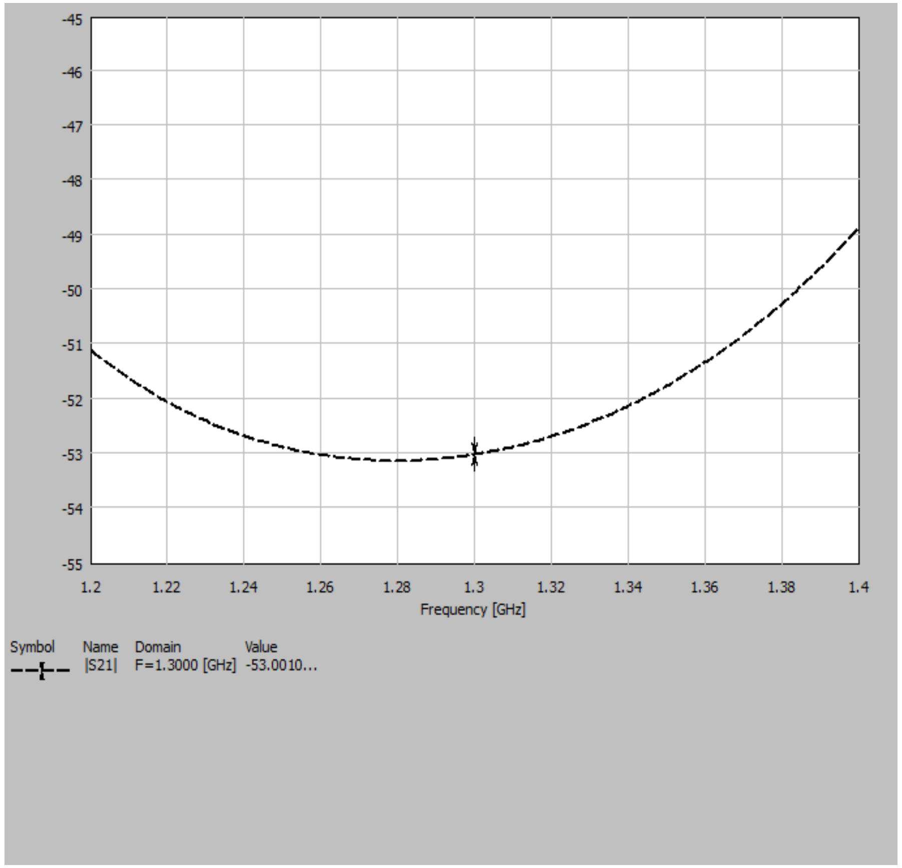


Without the tumour

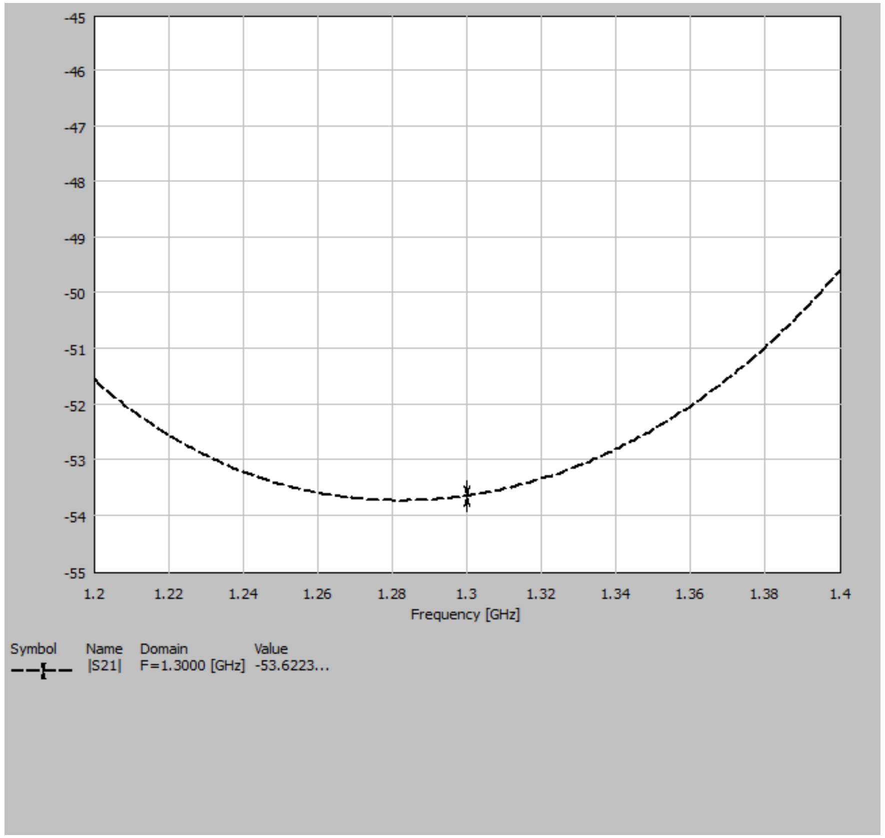


With the tumour

Comparison cont, S21 of new system at 1.3 GHz



Without the tumour



With the tumour

Conclusions

- The new system is more responsive to the presence of the tumour.
- The attenuation between the antennas is lower in the old system but this is probably due to directly coupled waves that does not propagate through the breast. The image reconstruction will not be able to benefit from these waves.
- The same results have been shown for the phase.
- The new antennas have also show the same response to tumour presence at the frequencies 2 and 3 GHz.