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Numerical and Experimental Evaluation of Phantoms for Off-Body Wireless Communications

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Introduction

❖Antennas for body-centric communication systems have been a growing area of research for a number of years, with potential for use in health monitoring, military, sport and entertainment applications. Antenna design should be carried out in situ with the limitations imposed by the human body where, for example, a reduction in size may be more beneficial than a good match. Numerical and physical phantoms have been developed in order to accurately measure the performance of antennas placed on the body.

The Phantoms

- ❖Phantoms are required to allow full on-body 3 dimensional radiation patterns to be measured.
- ❖Electromagnetic properties of the human body vary depending on the type of tissue. For body-worn antennas, the most influential tissues are muscle, fat and skin.
- ❖Permittivity of phantom used for measuring body-worn antennas can be an average value of between 35-50.
- ❖Physical phantom composed of a mixture of TX151, Polythene Powder and water:

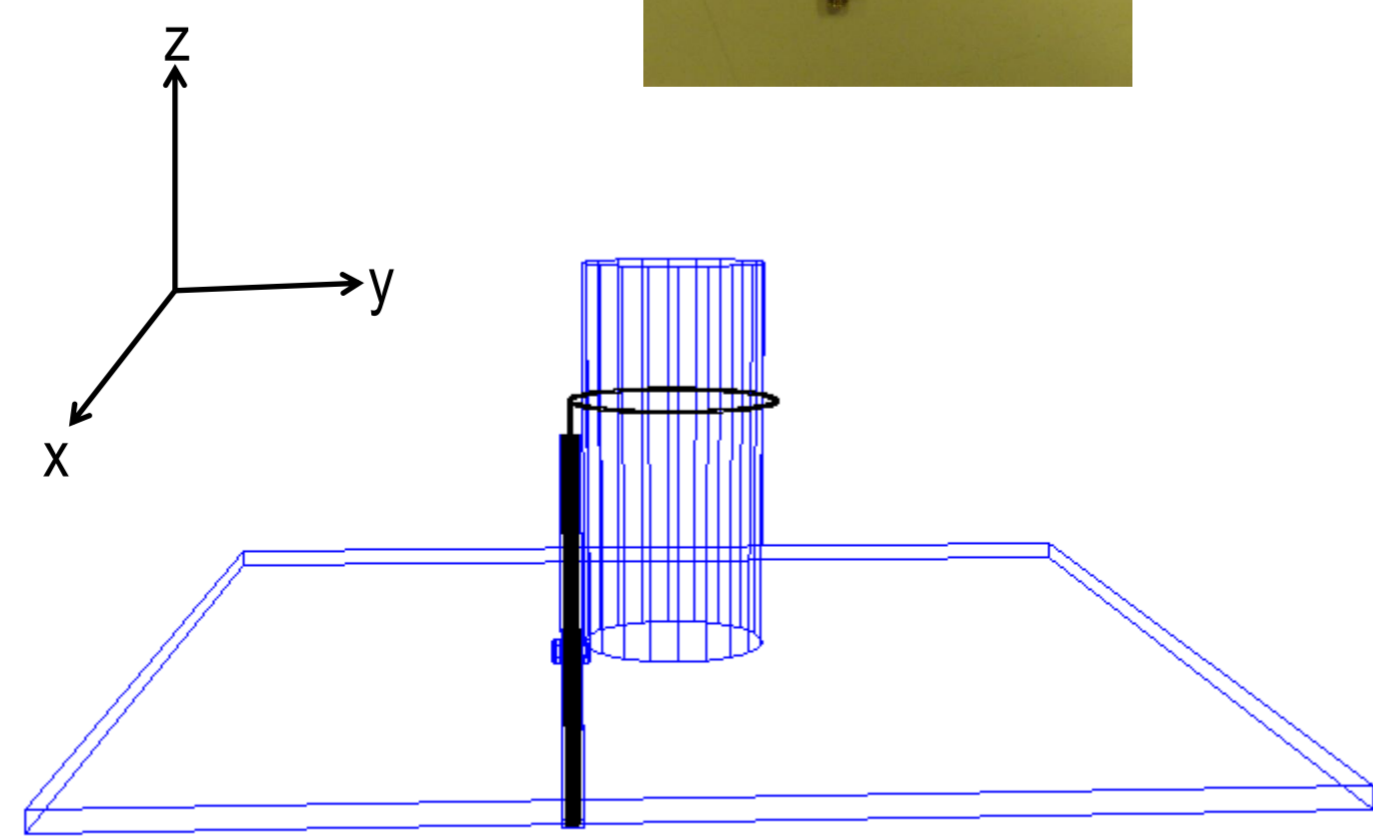
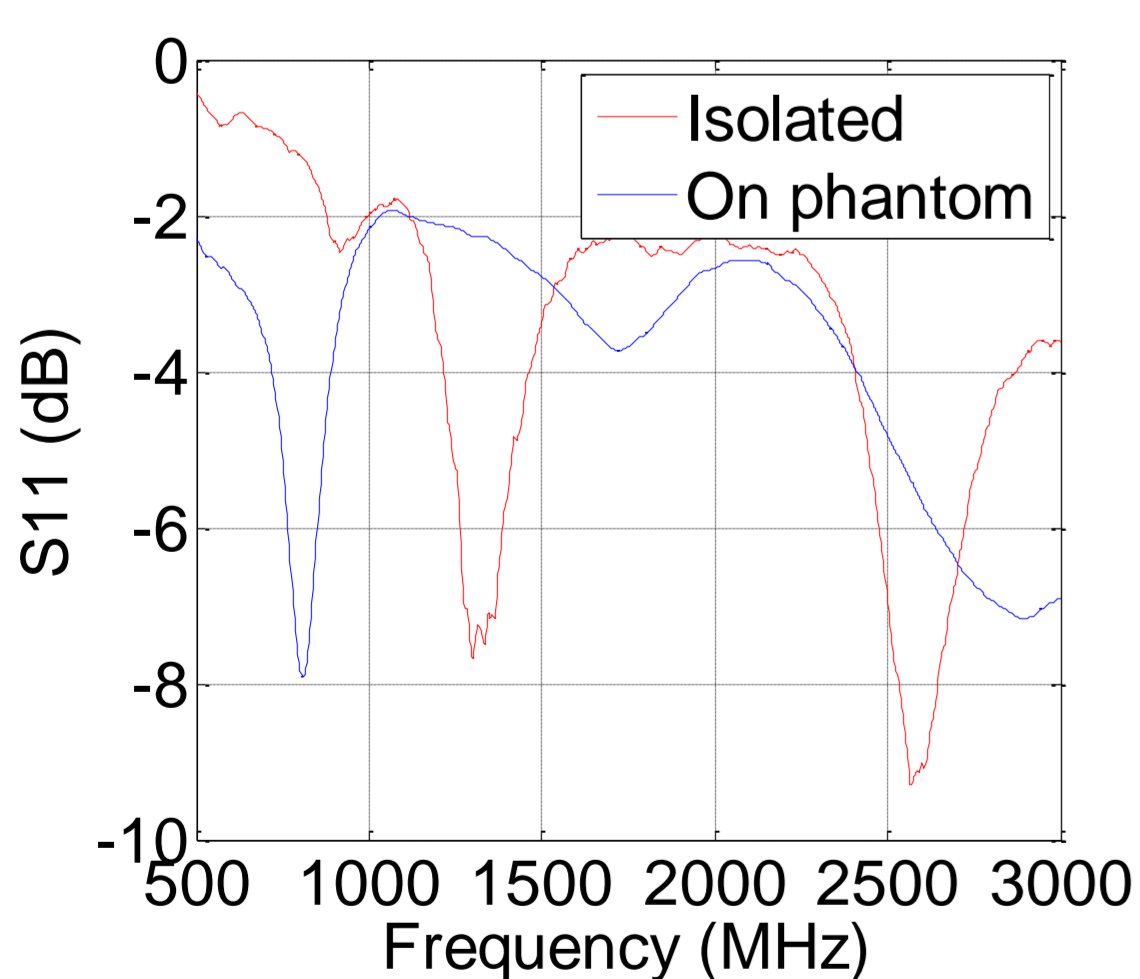
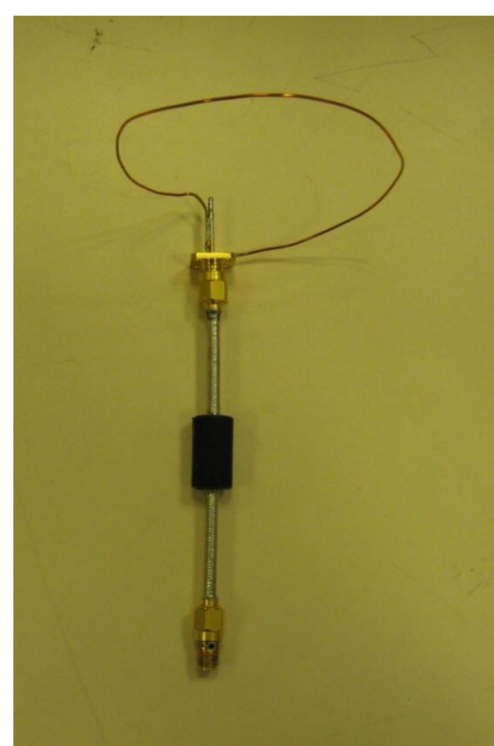
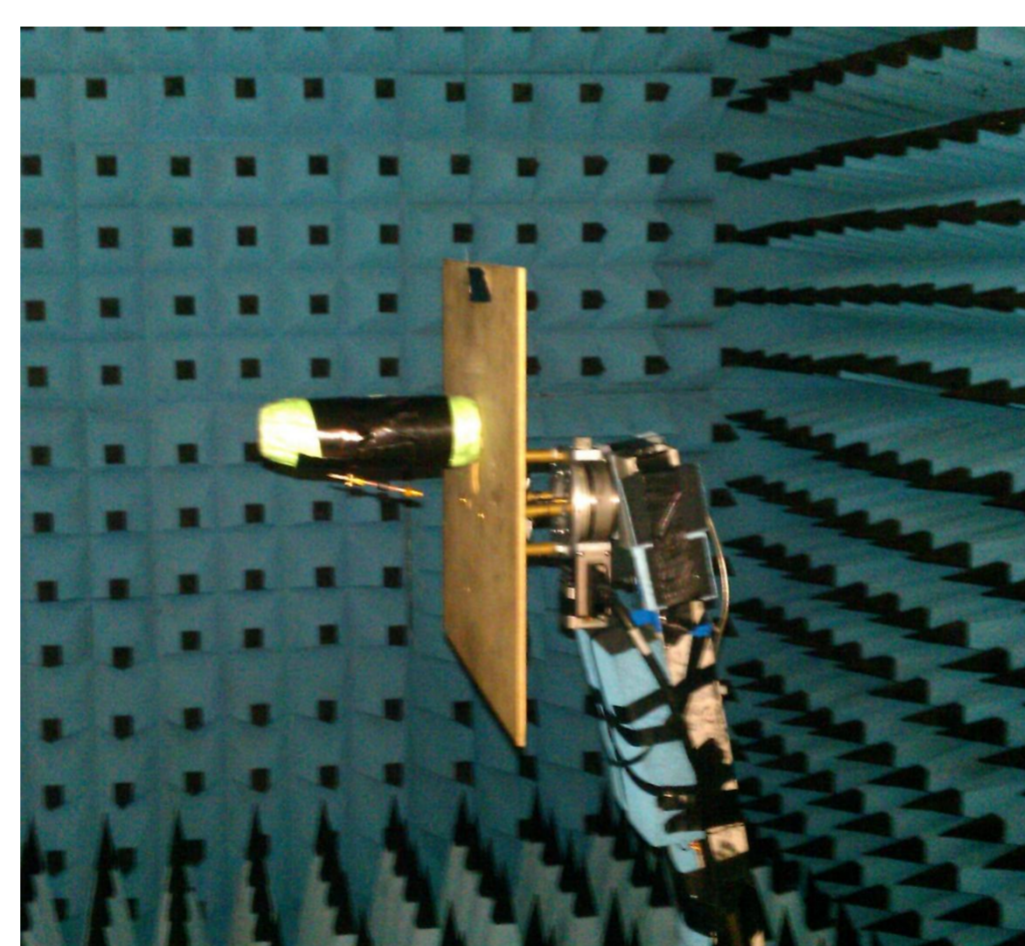
Relative Permittivity	Conductivity	Penetration Depth
46	2.1s/m	5dB/cm



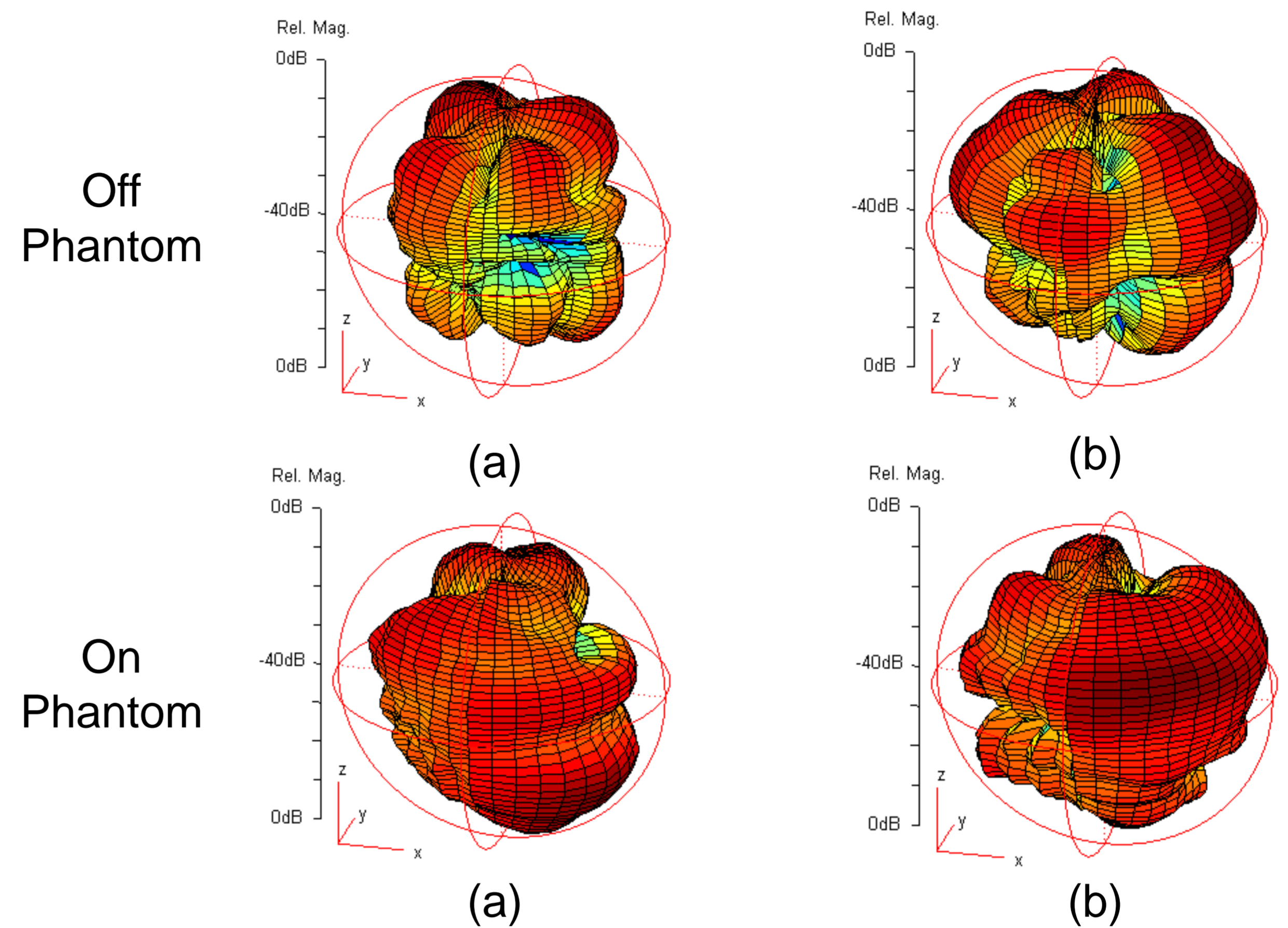
- ❖Numerical phantom was created using the FDTD method and was given same relative permittivity and conductivity as the measured values. Cell size kept to below $\lambda_g/20$ to avoid reflections.
- ❖Phantom was placed in close proximity to a patch antenna and found to have a similar detuning effect to the human body.

Effects on Radiation Pattern of Loop Antenna - Design

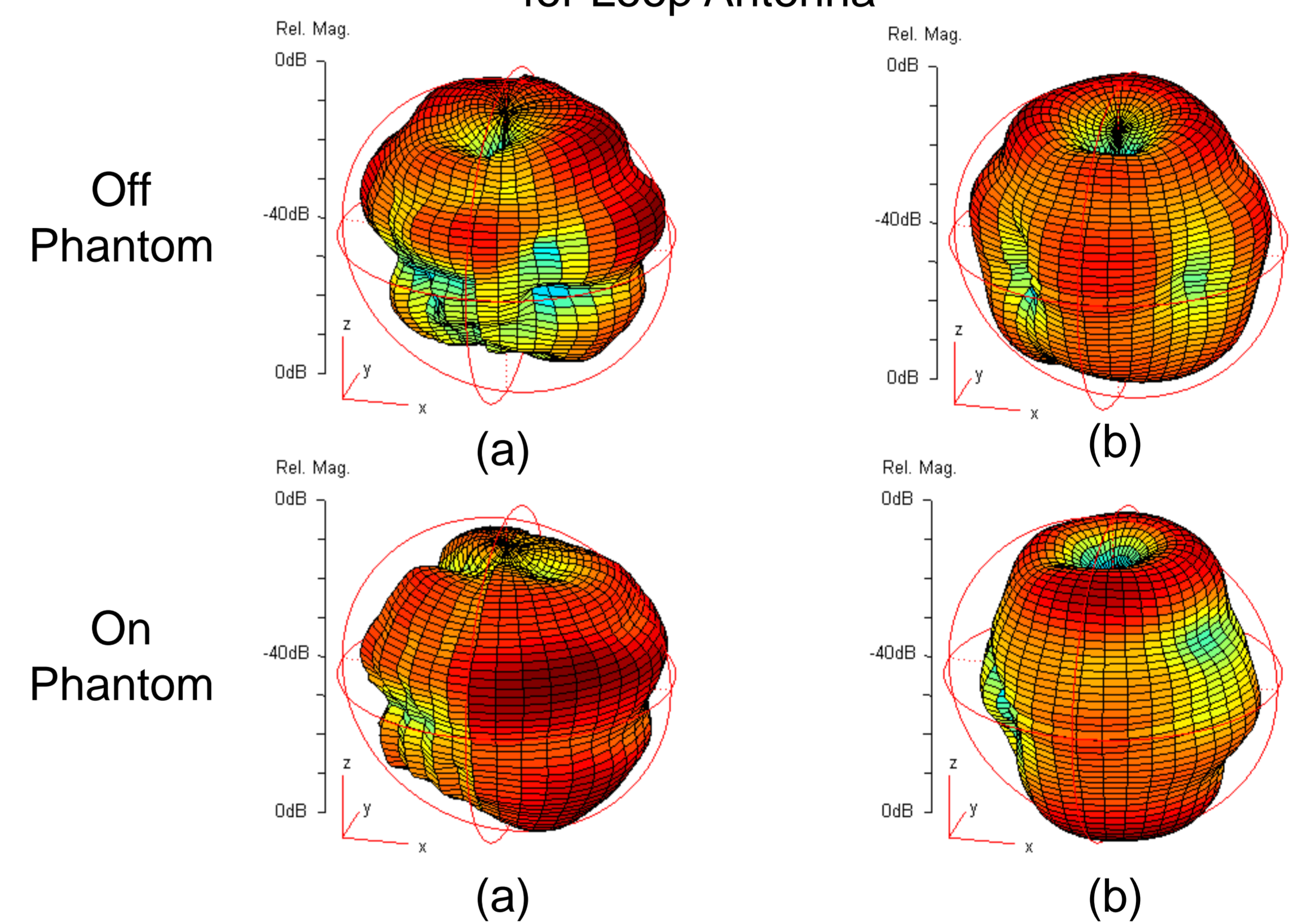
- ❖Radiation Pattern of a Loop antenna with radius 37mm was measured on and off the phantom, which was rolled into a cylindrical arm shape.
- ❖The patterns were measured at 2.4GHz, a frequency that is similar to many wireless standards used for health monitoring applications, such as Zigbee or 802.11b/g.
- ❖Because the antenna was designed to fit around the phantom, at this frequency the antenna was electrically large. Here, comfort and practicality took preference over a well matched response.



Effects on Radiation Pattern of Loop Antenna - Results



Measured Vertical (a) and Horizontal (b) Radiation Patterns for Loop Antenna



Measured (a) and Simulated (b) Power Patterns for Loop Antenna

	Without Phantom	With Phantom
Max. Measured Radiation (dB)	-52.31	-62.81
Max. Directivity (dBi)	6.4	5.4
Relative Gain (dB)	6.4	-3.8
Rel. Efficiency (Meas.)	-	12+/-4%
Rel. Efficiency (Sim.)	-	8%

Radiation Characteristics of Loop Antenna

- ❖Measured efficiency of the loop antenna is reduced by 88% when it is placed on the phantom compared to when it is not on the phantom.
- ❖Diffraction around the edge of the wooden base are present in the patterns. These may be similar to diffractions around the torso for some body worn antennas, and will be investigated in future work.
- ❖Simulated Patterns and efficiencies agree with measured results.

Conclusions

- ❖Phantom has been created and evaluated for use with design and measuring antennas for body-centric communication systems.
- ❖Phantom was found to have a similar detuning effect as the body when placed in close proximity to a patch antenna.
- ❖When a loop antenna was placed on the phantom, its efficiency was reduced by 88% compared to when it was not on the phantom.