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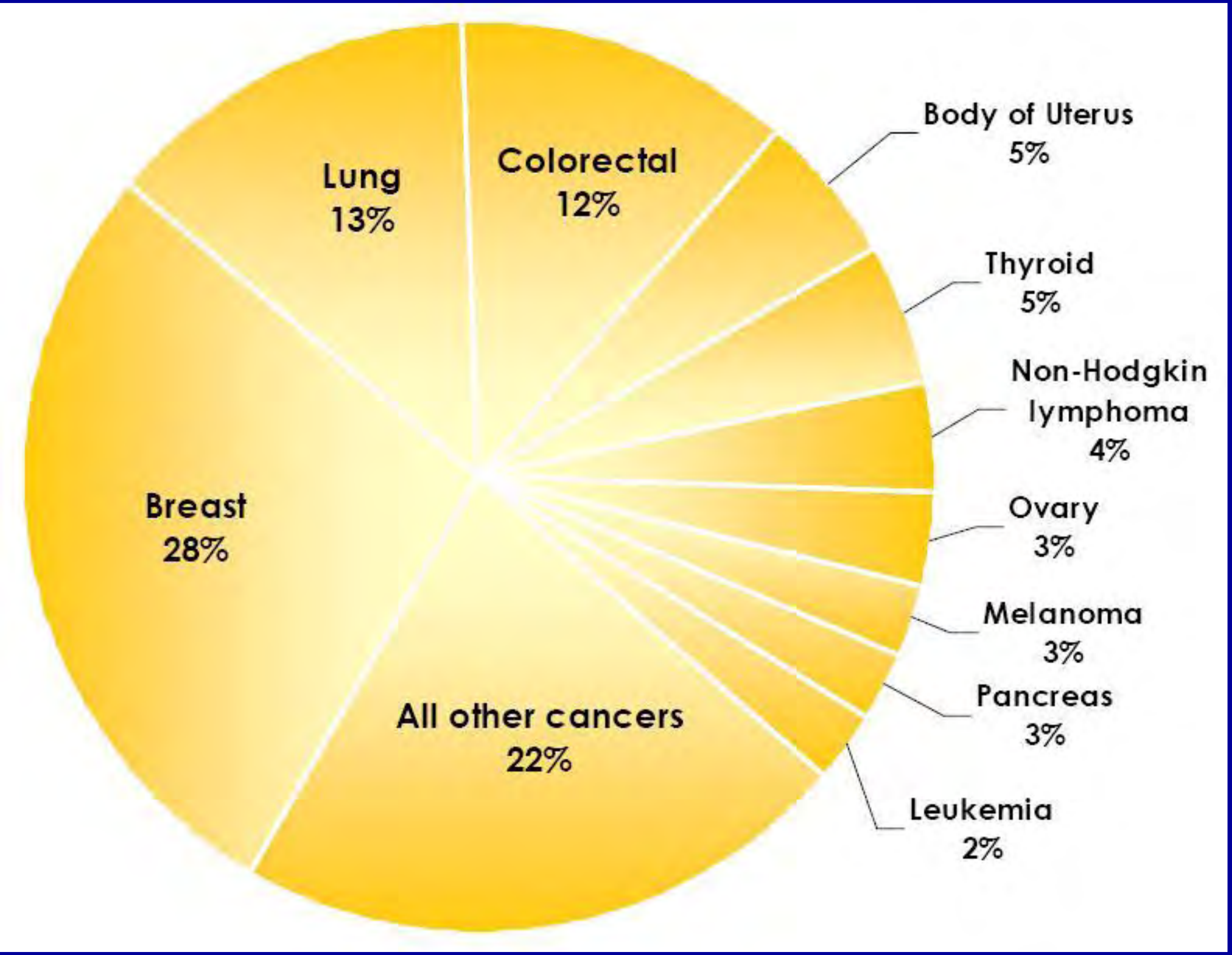
Modeling of Tumor Location Effect in Breast Microwave Imaging Using COMSOL

Elham Khosrowshahli
School of Biomedical Engineering
Aleksandar Jeremic
Department of Electrical and Computer Engineering
McMaster University

Outline

- Motivation
- Breast cancer screening
- Microwave Imaging
- Theory
- COMSOL simulation
- Results

Top 10 cancers in women Canada, 2010



Supplementary Figures, Canadian Cancer Statistics 2010, Canadian Cancer Society

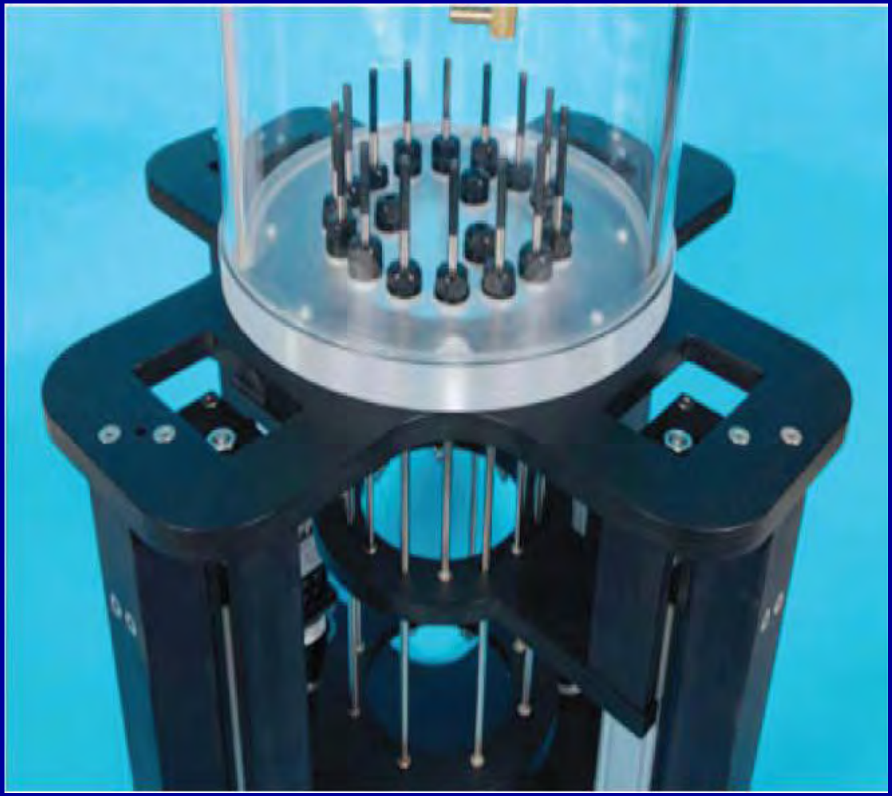
Breast Cancer Screening

- Mammography
- Ultrasound
- MRI
- Microwave

Microwave Imaging

Fear, E.C. wt al. , "Enhancing breast tumor detection with near-field imaging," *Microwave Magazine, IEEE* , vol.3, no.1, pp.48-56, Mar 2002

Microwave Imaging



Meaney, P.M. et al. , "Clinical microwave breast imaging — 2D results and the evolution to 3D," *Electromagnetics in Advanced Applications, 2009. ICEAA '09. International Conference on* , vol., no., pp.881-884, 14-18 Sept. 2009

Maxwell's Equations

$$\nabla \times E = -j\omega\mu H$$

$$\nabla \times H = J + j\omega\varepsilon E$$

$$\nabla \cdot E = \rho / \varepsilon$$

$$\nabla \cdot H = 0$$

source-free

→

medium

$$\nabla^2 E + k^2 E = 0$$

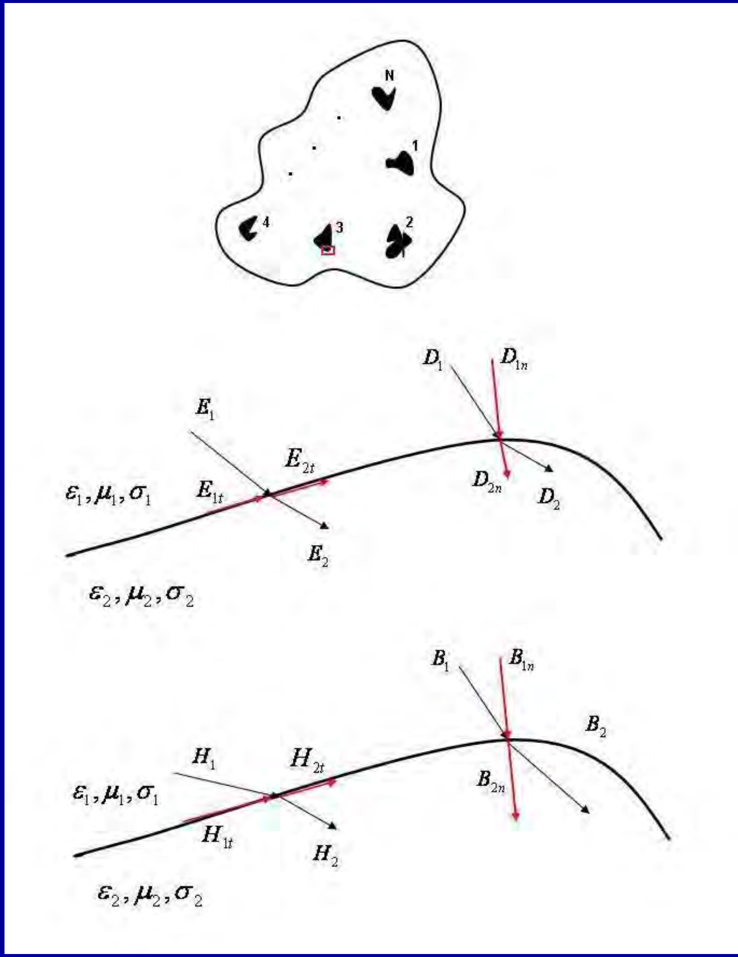
$$\nabla^2 H + k^2 H = 0$$

$$k = \omega\sqrt{\mu\varepsilon}$$

$$\varepsilon = \varepsilon' - j\varepsilon''$$

$$\varepsilon'' = \frac{\sigma}{\omega}$$

Medium with Scatterers



$$\hat{n} \times (E_1 - E_2) = 0$$

$$\hat{n} \times (H_1 - H_2) = J_s$$

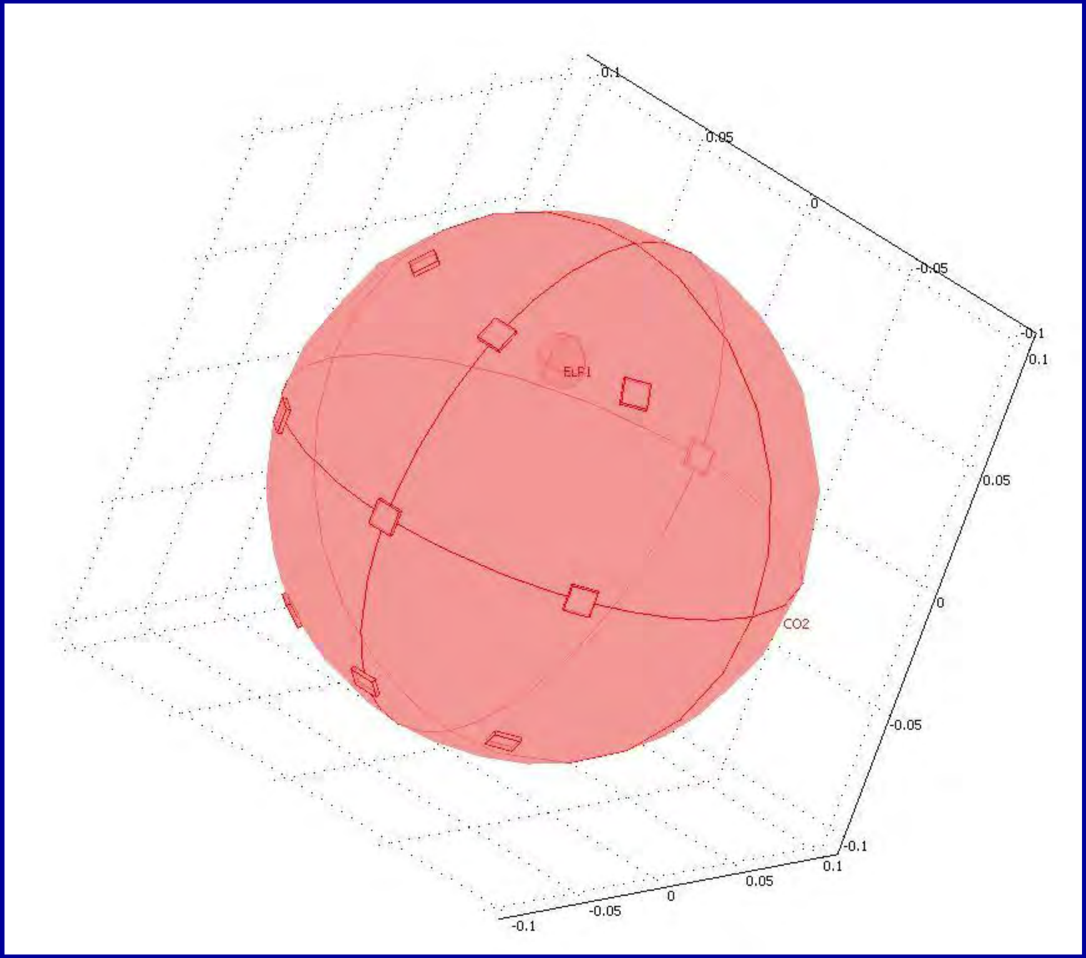
$$\hat{n} \cdot (D_1 - D_2) = \rho_s$$

$$\hat{n} \cdot (B_1 - B_2) = 0$$

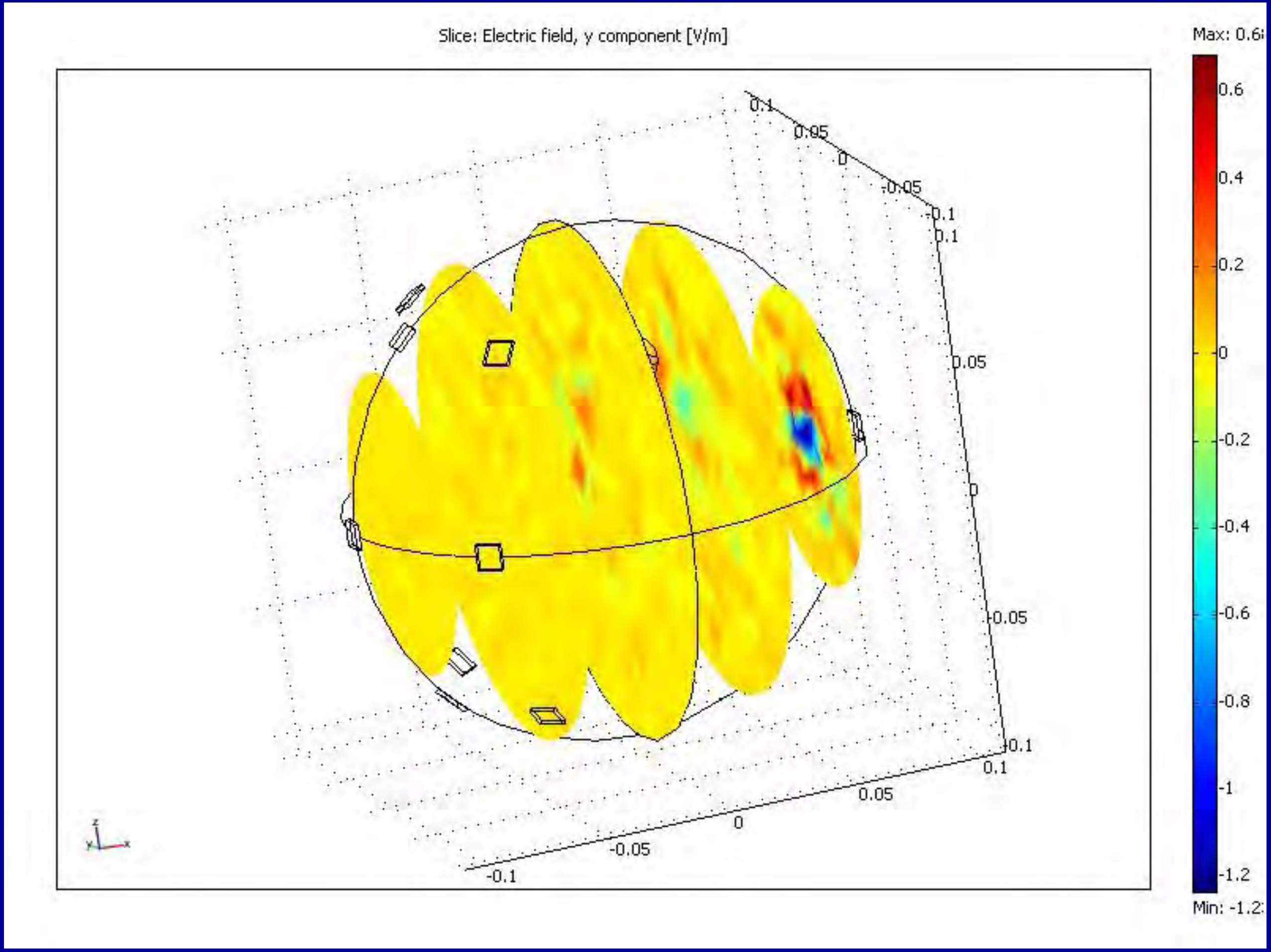
Inverse Model

- Classical: minimize error between model predicted and measured (simulated)
- Stochastic: substitute classical least square function with minimization of expected value
- Choice of random vectors?
- Computational time and/or accuracy ?

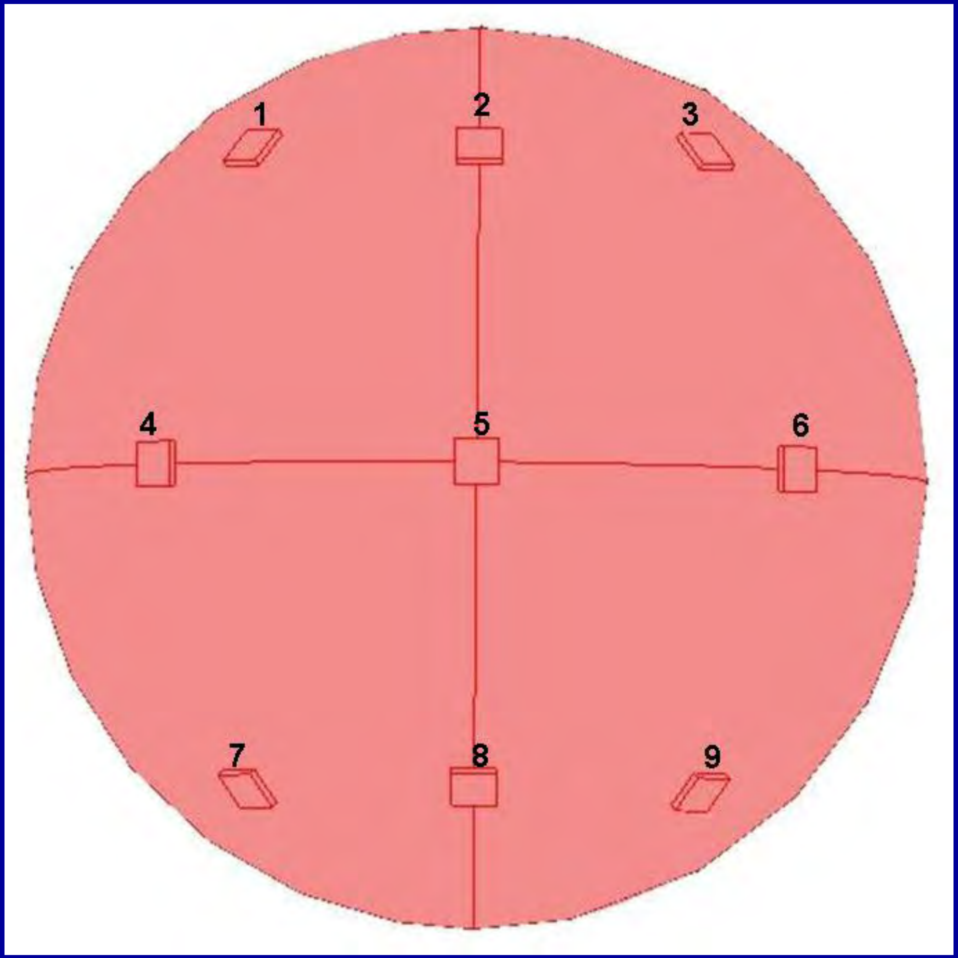
Geometry of Eccentric Tumor



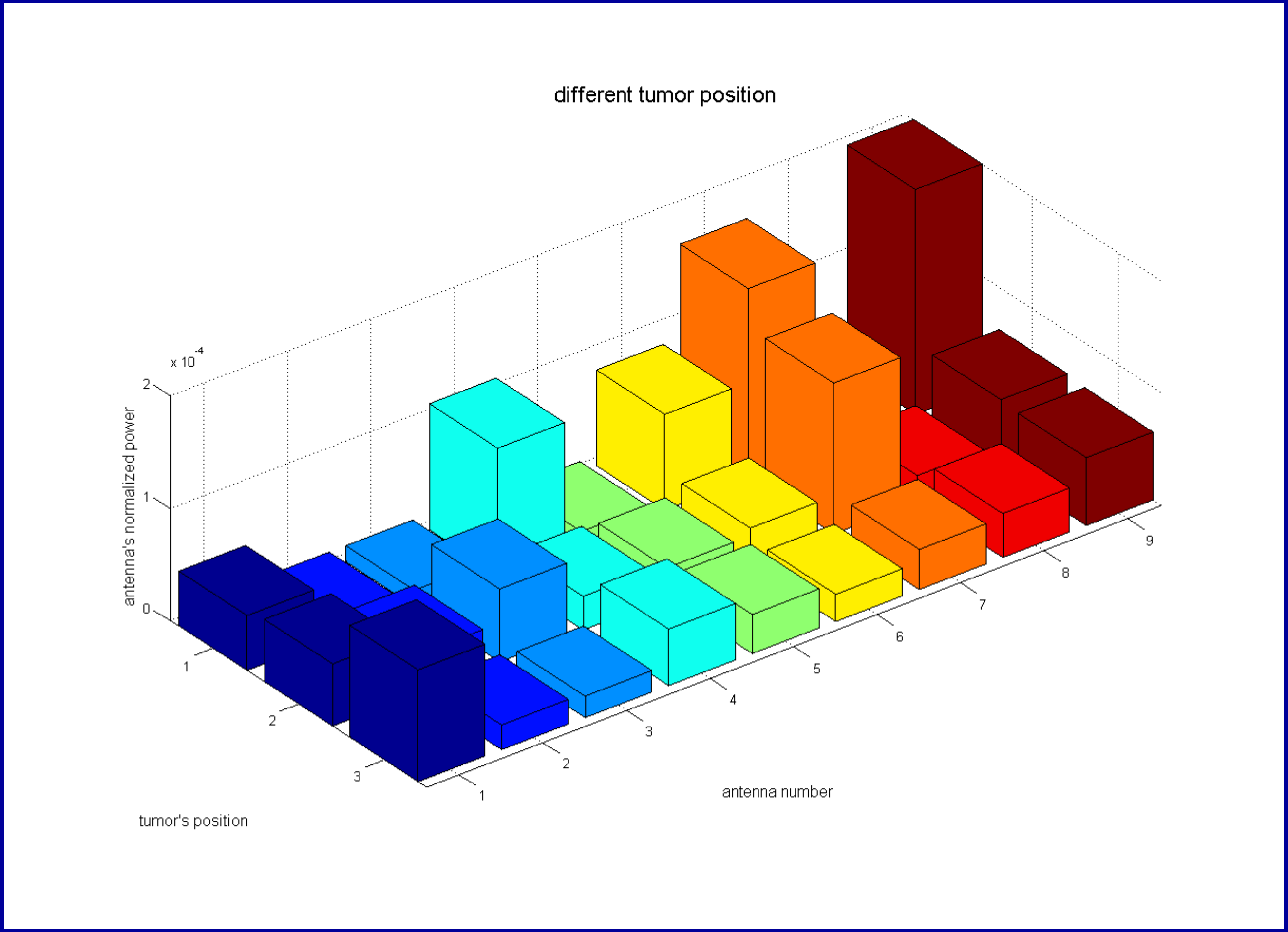
E_y for Eccentric Tumor



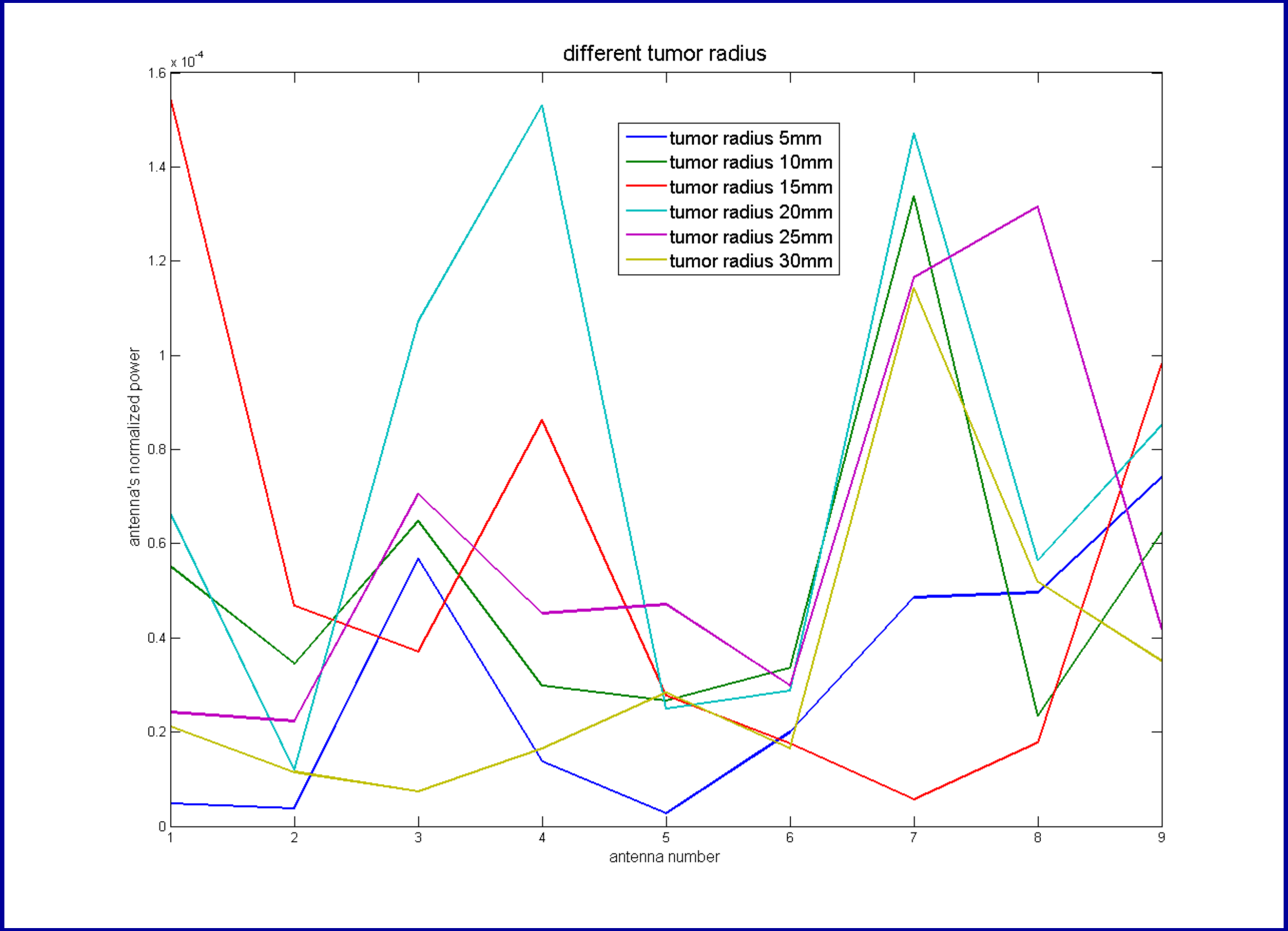
Receiving Antennas Numbering



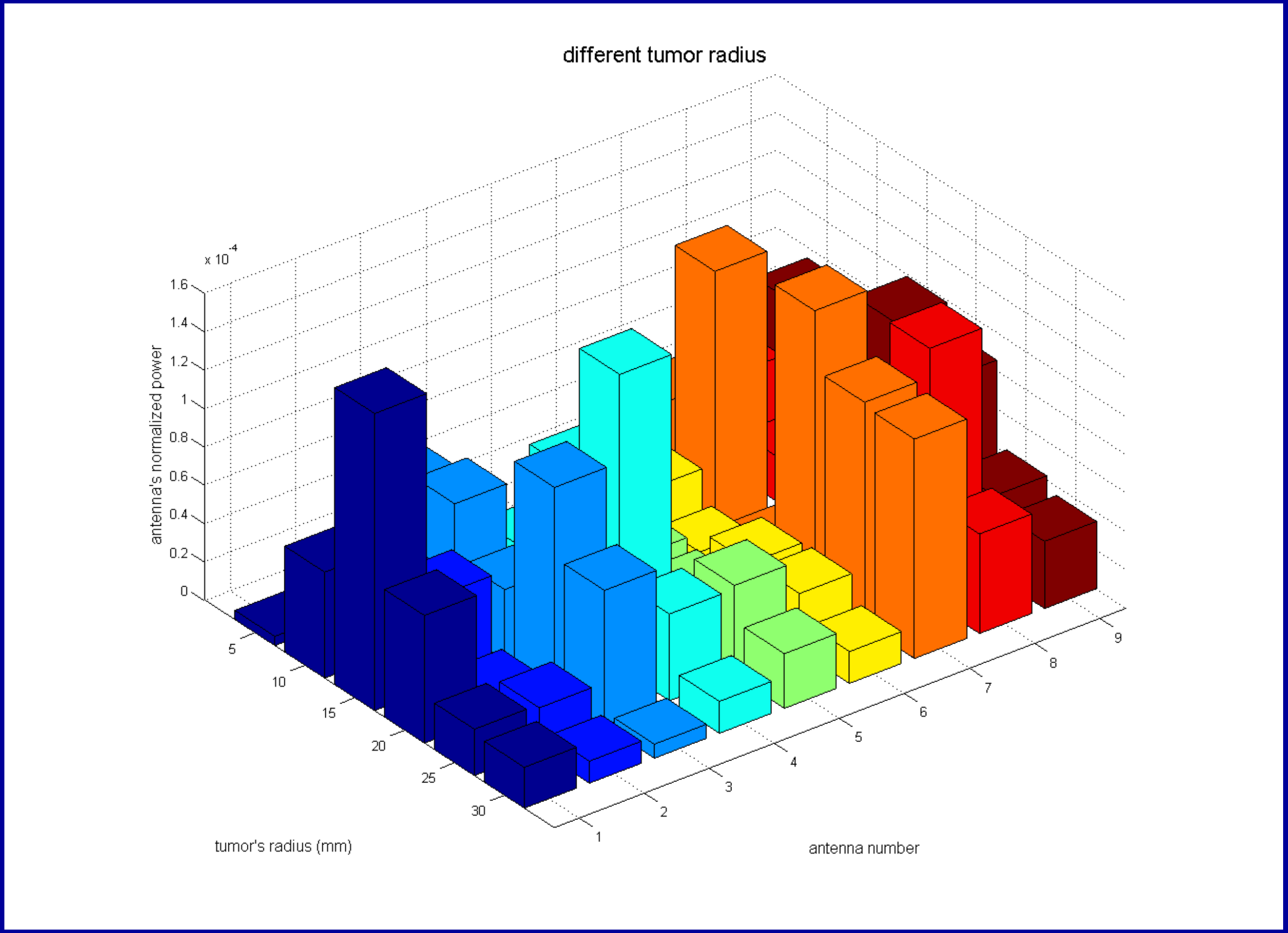
Effect of tumor location on measured signal of receiving antennas



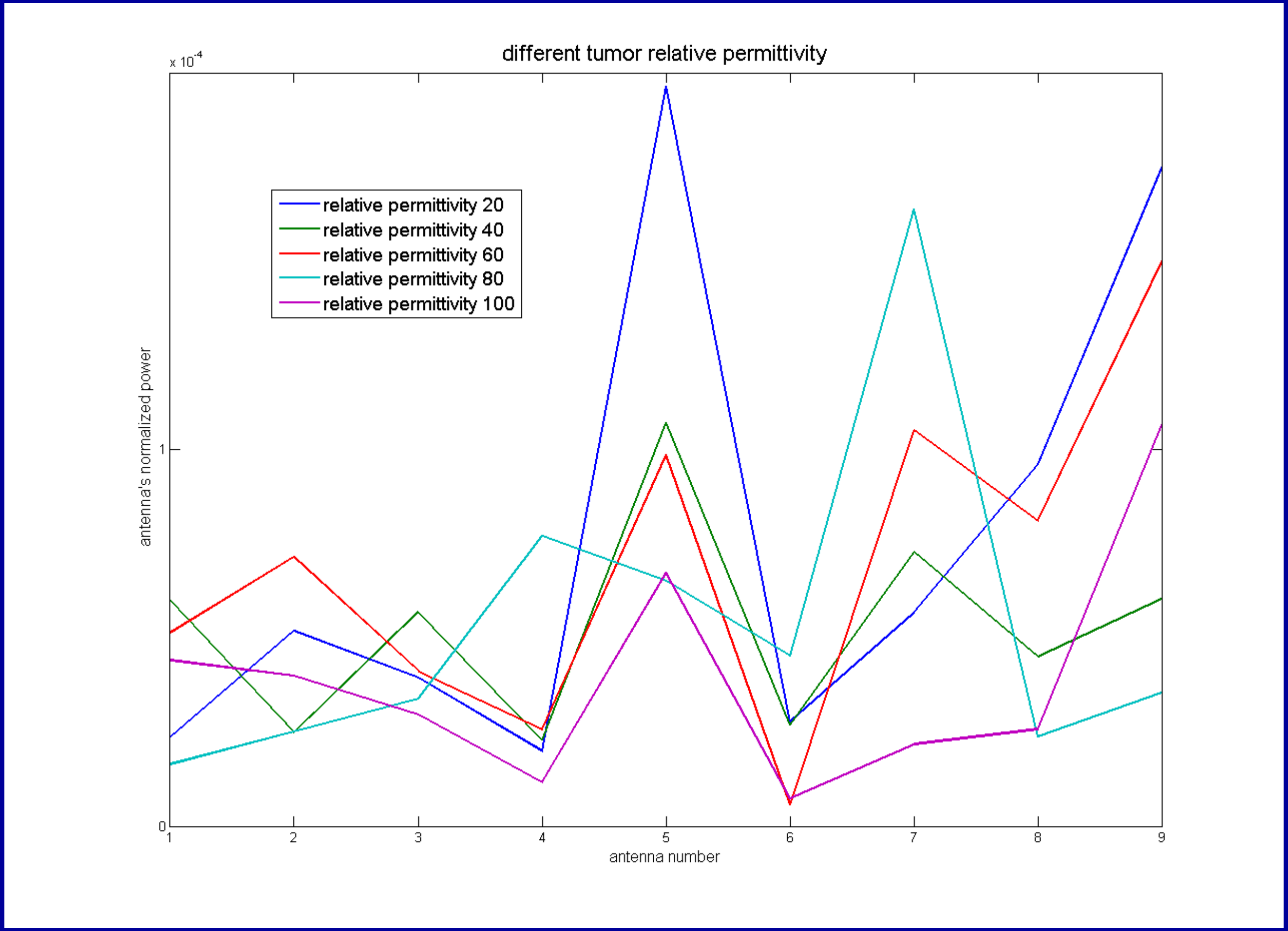
Effect of tumor size on measured signal of receiving antennas



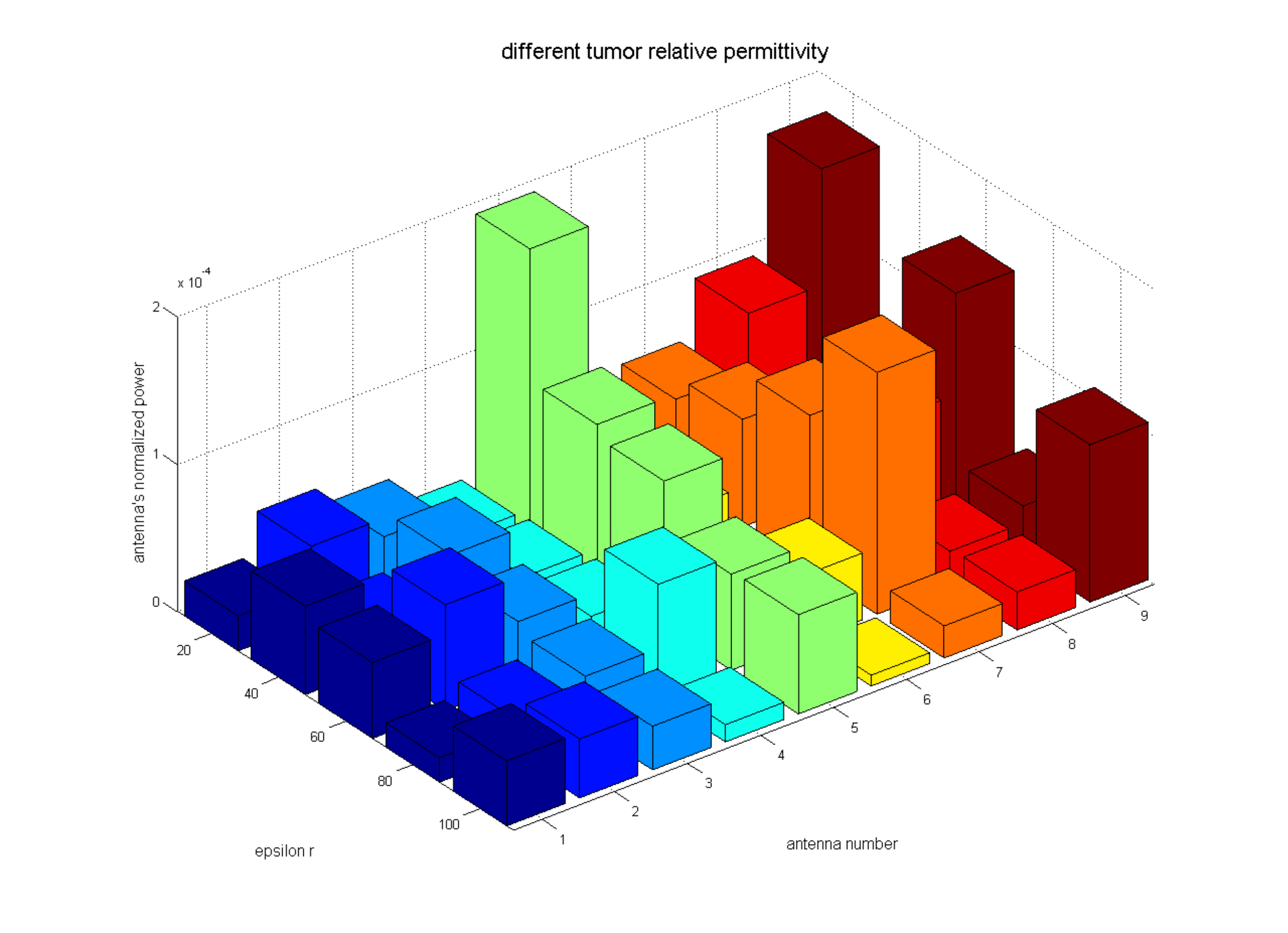
Effect of tumor size on measured signal of receiving antennas



Effect of tumor relative permittivity on measured signal of receiving antennas



Effect of tumor relative permittivity on measured signal of receiving antennas



Inverse Model

- Comparison

Method	Computational Time	MSE
Deterministic	Approx. 60	21%
Stochastic	1	24%

Future Research

- Inverse modelling using stochastic optimization
- Experimental prototype in order to determine noise levels
- Adequate signal processing to address important issues: dense breasts, 3D of microwaves vs 2D of mammography, etc.