Partnerships for Research on Microelectronics, Photonics and Telecommunications

prompt

NSERC CRSNG

hSITE
Healthcare Support through Information Technology Enhancements

Microwave Breast Cancer Screening

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McGill
ELECTRICAL AND COMPUTER ENGINEERING
Computational Electromagnetics Laboratory

Fonds de recherche Nature et technologies Québec

Motivation

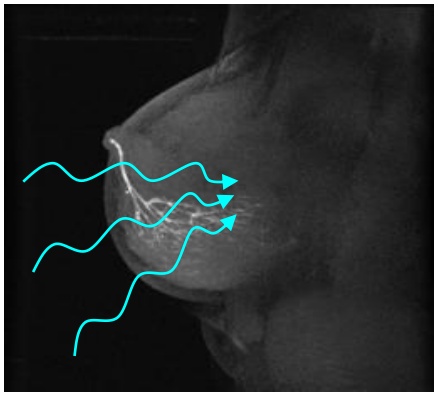
* **Breast cancer:** Most common cancer in Canadian women; 1 in every 9 will be diagnosed during life
* **Early detection:** Drastically increases survival rate

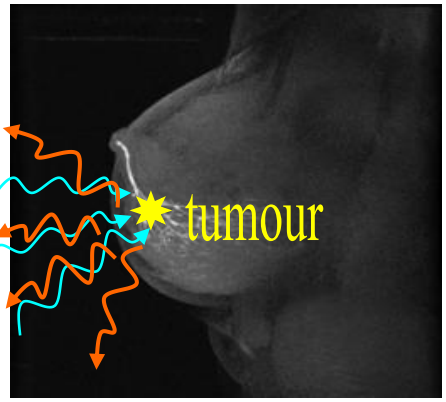
* 5-year survival rate (2011, USA):
  * 98% for localized tumours
  * 84% for regional spreading
  * 23% for distant spreading

Sources: Canadian Breast Cancer Foundation, American Cancer Society

Microwave Techniques

* **Mammography:**
  * breast compression; ionizing radiation
  * effective but still high rate of false positives & negatives
* **Microwave methods:**
  * non-invasive; no ionizing radiation
  * no pain or discomfort; potentially cost-effective
  * Possible complementary technique to currently used modalities
  * Exploits contrast in dielectric properties of healthy and tumorous breast tissues over microwave frequencies





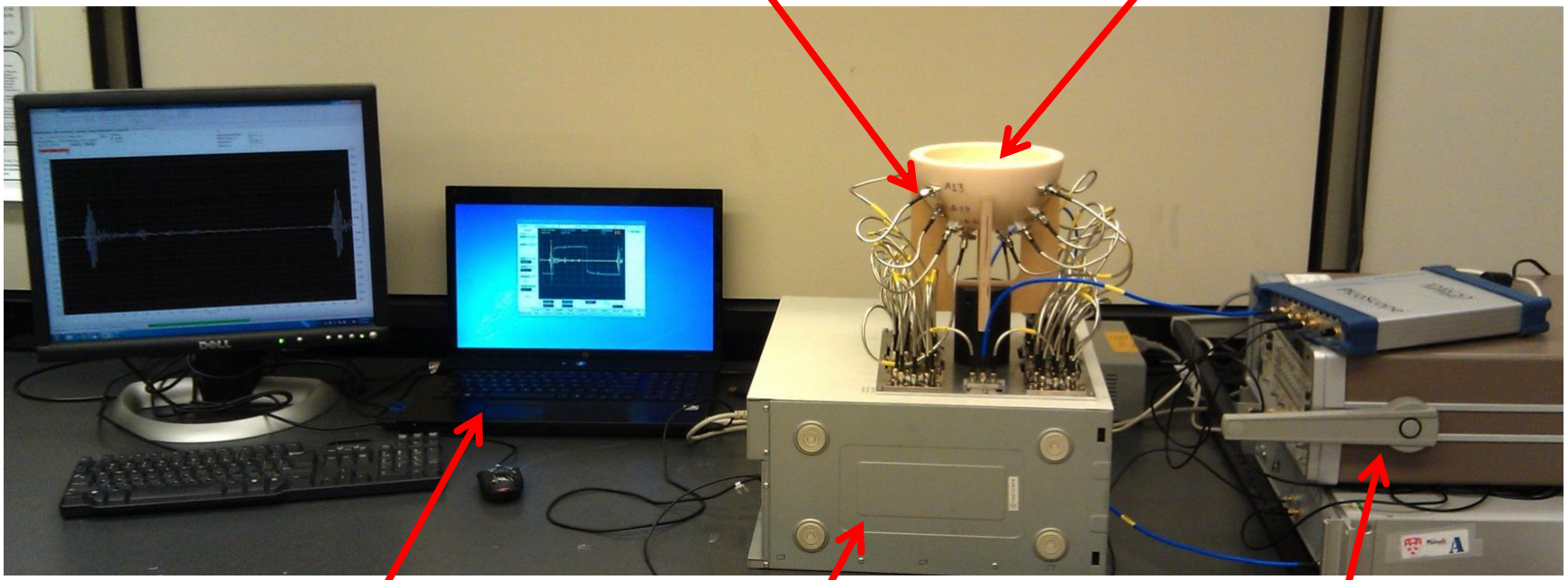
Source: Kanj 2007

Concept: Microwave Time-Domain Breast Cancer Detection

* Healthy patient undergoes regular breast monitoring
* Compare past and current scans
  * determine if any abnormalities have developed

* Goal: home use system
  * Easy, fast, comfortable, safe
  * Provides warning if results are unusual
  * Patient follows-up with doctor

Our System: Prototype



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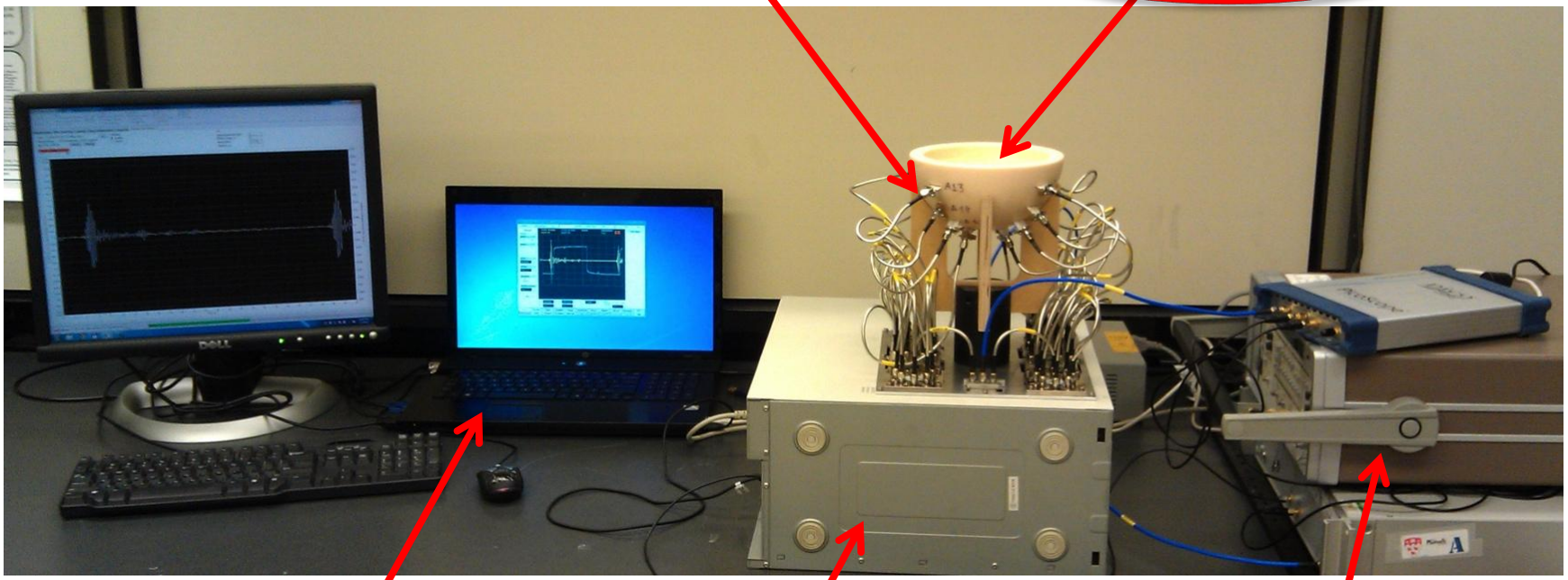
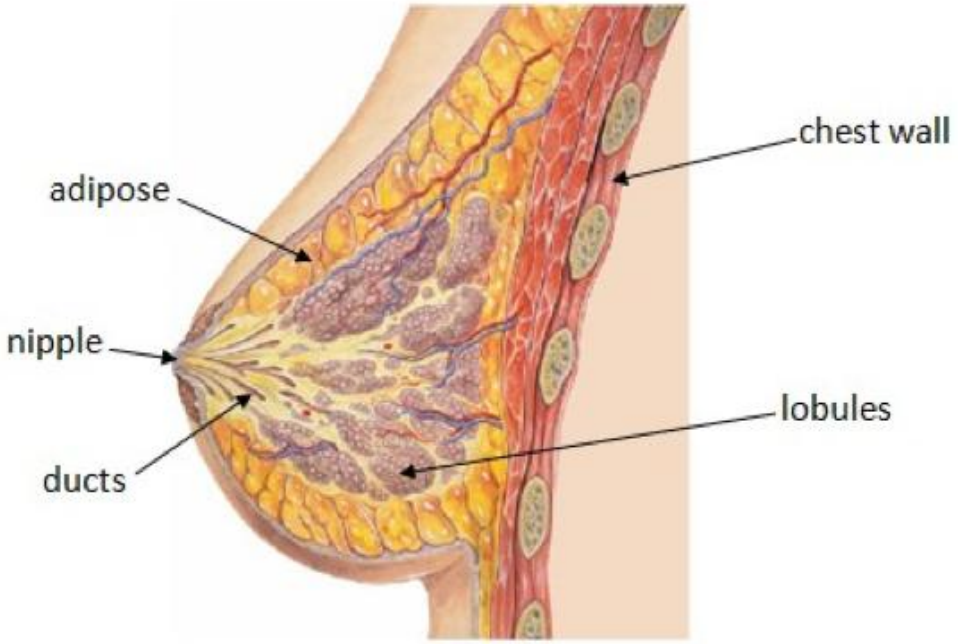


Human Breast Physiology

Tissue types:

* Skin
* Mammary glands
* Fat
* Tumour(s)



Adapted from: Infrared Medical Solutions.

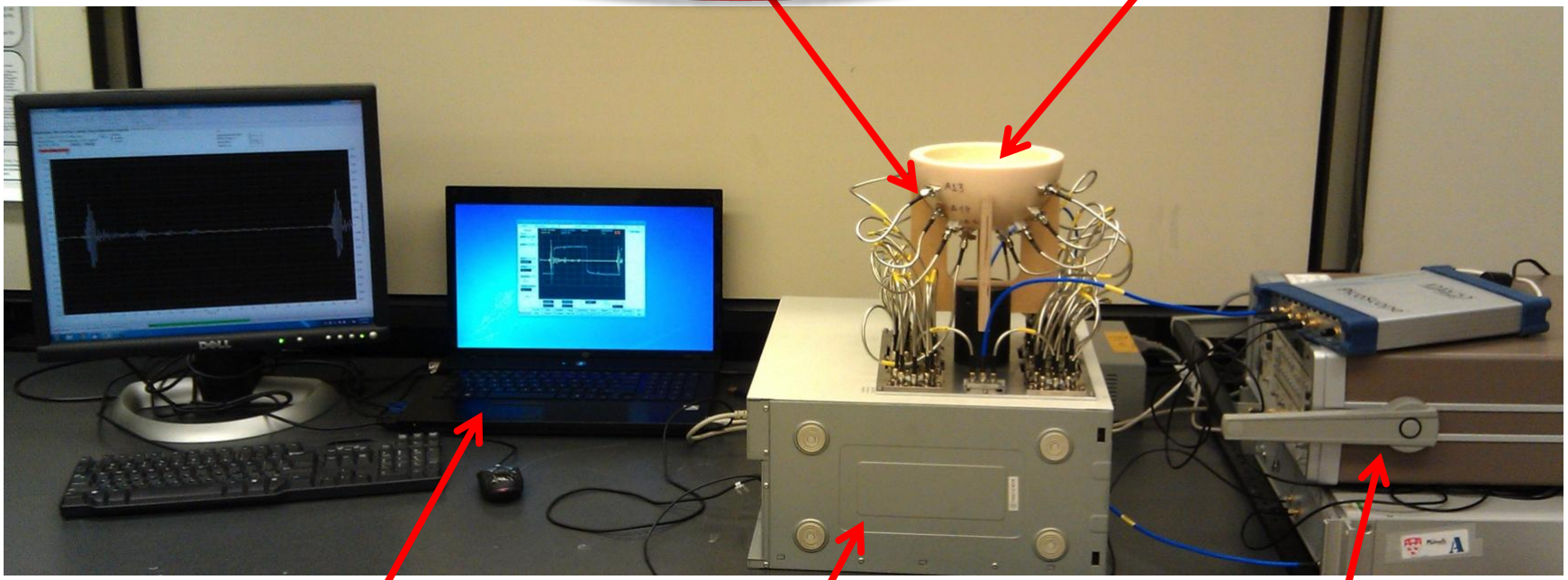
Phantom Construction

* Tissue models mimic relative permittivity and conductivity of actual breast tissue
  * Fat, skin, gland and tumour mimicking materials with unique properties
* Made from common, easy to obtain chemicals
* Dielectric properties controlled by oil to water ratio

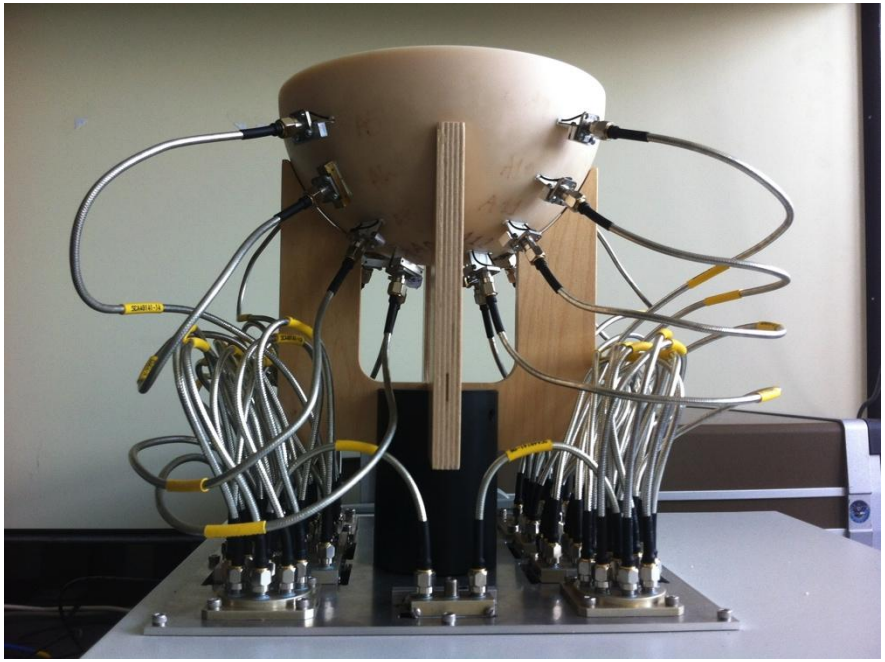
Tissue Phantom Design

* Complete phantoms (all 4 tissues combined):
  * Hemispherical
  * Realistically-shaped

Our System: Overview



Our System: Antenna array



* 16-element array
* 2 – 4 GHz
* Hemispherical bowl-shaped radome

* Time-domain measurements

Travelling Wave Tapered and Loaded Transmission Line Antenna (Kanj 2008)

Radiation efficiency = 39%

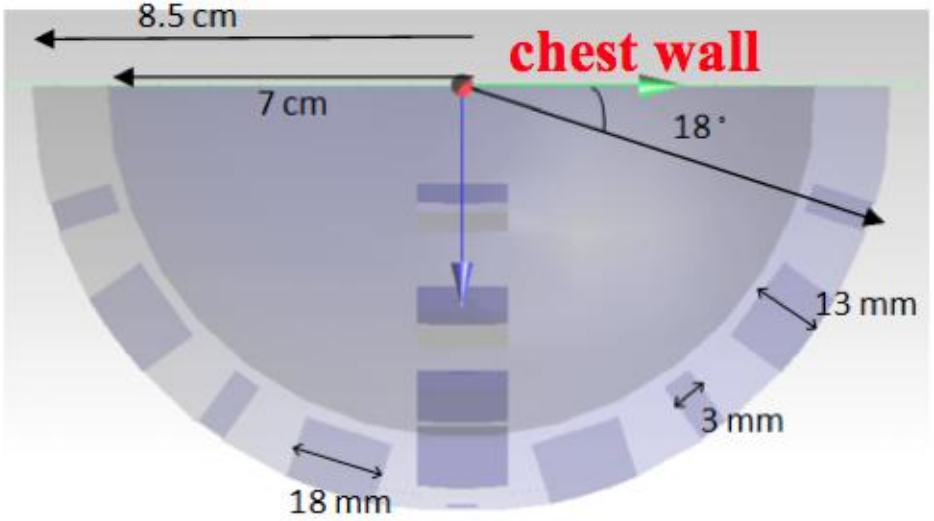
Signal fidelity = 0.95

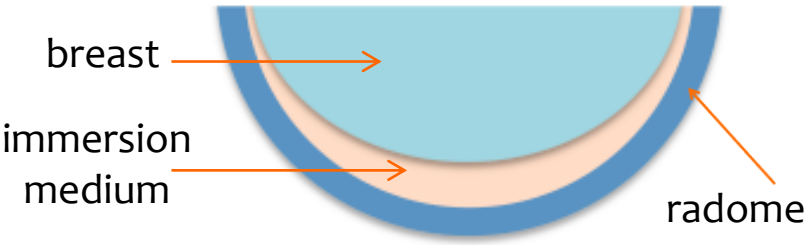
Designed for biosensing applications

0.635 x 12 x 15.8 mm^3

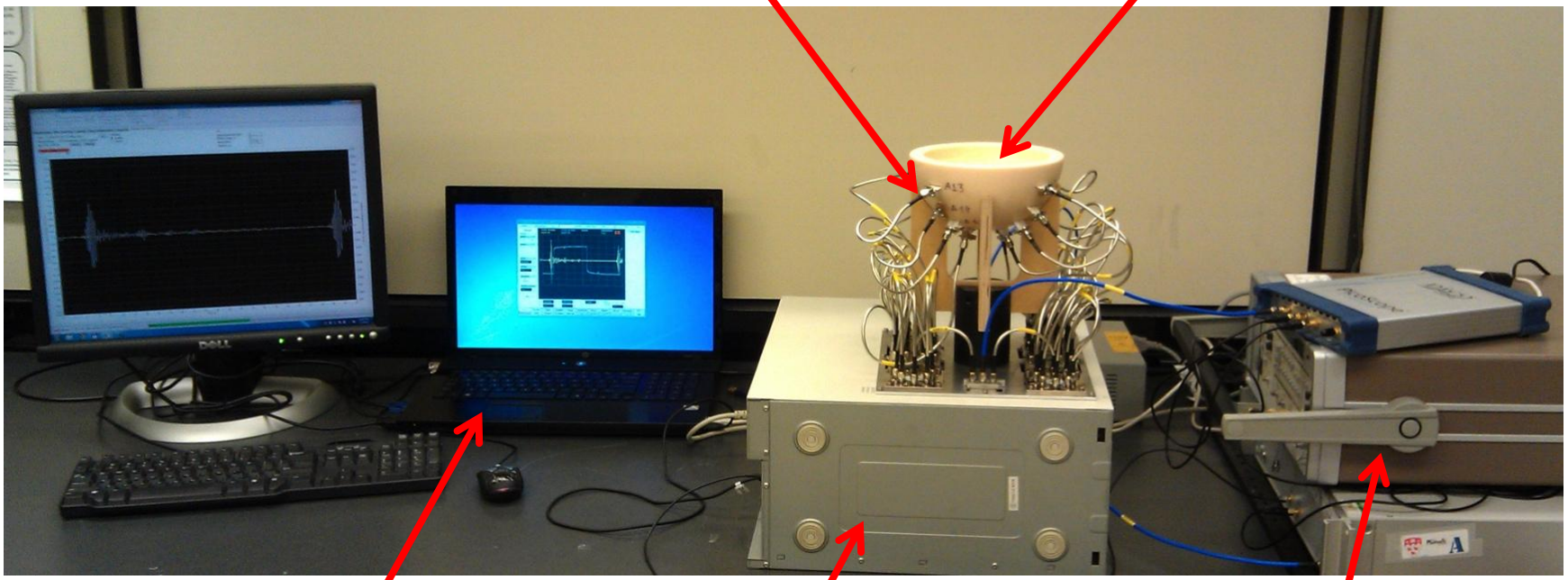
Radome Description

- Alumina, $\varepsilon_r = 9.6$
- 16 slots for antenna
- Co- & cross-polarized positions
- Ultra-sound gel to prevent airgaps
  - Approved for medical use
  - Lossy at microwave frequencies: attenuates signals not travelling directly through breast

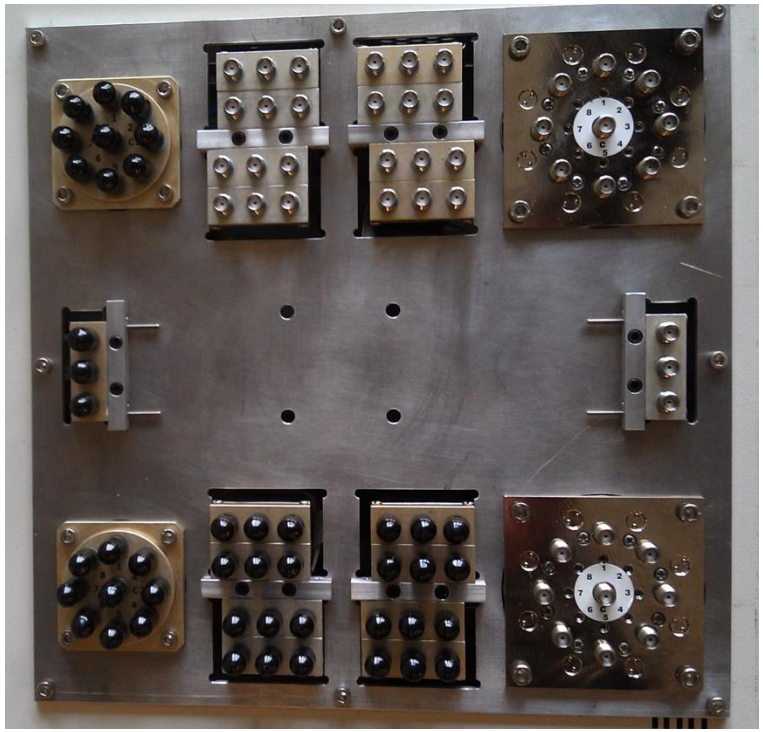




Our System: Overview

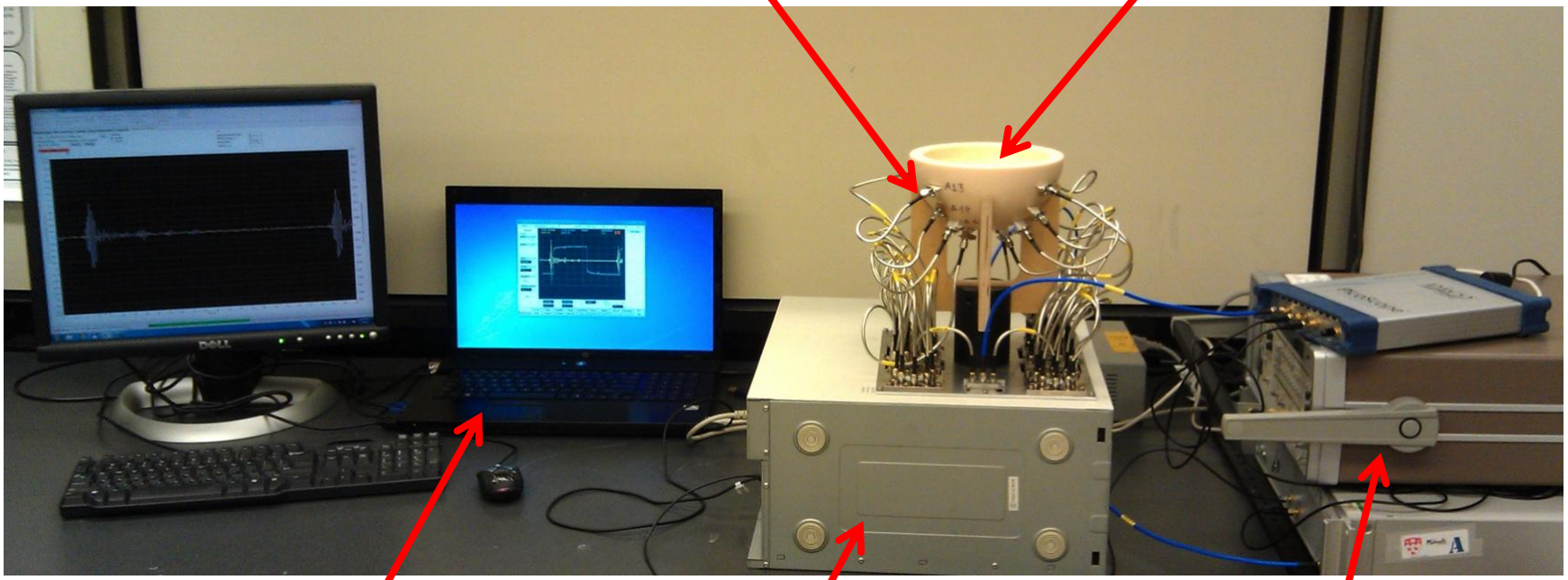


Switching Network



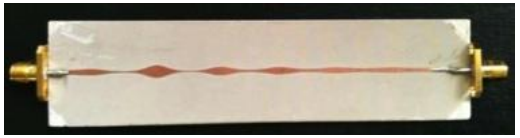
* Fully automated switching network
  * Connects antennas to input/output
* Does a full scan of transmit/receive antennas

Our System: Overview



Pulse Generation & Data Collection

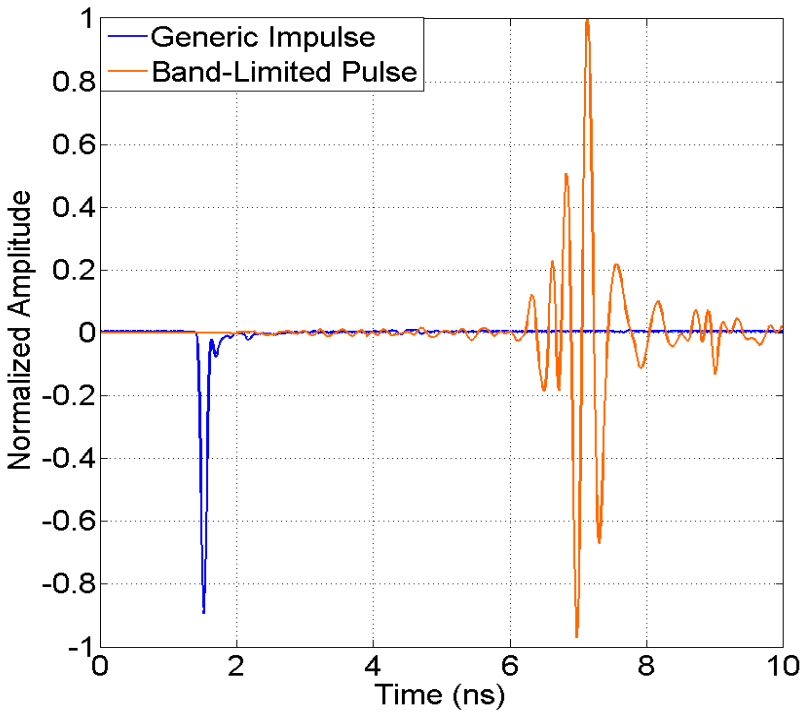
* Pulse Generator
  * 70 ps duration pulses
  * Shaped with synthesized broadband reflector (SBR) for concentrated energy in 2-4 GHz range

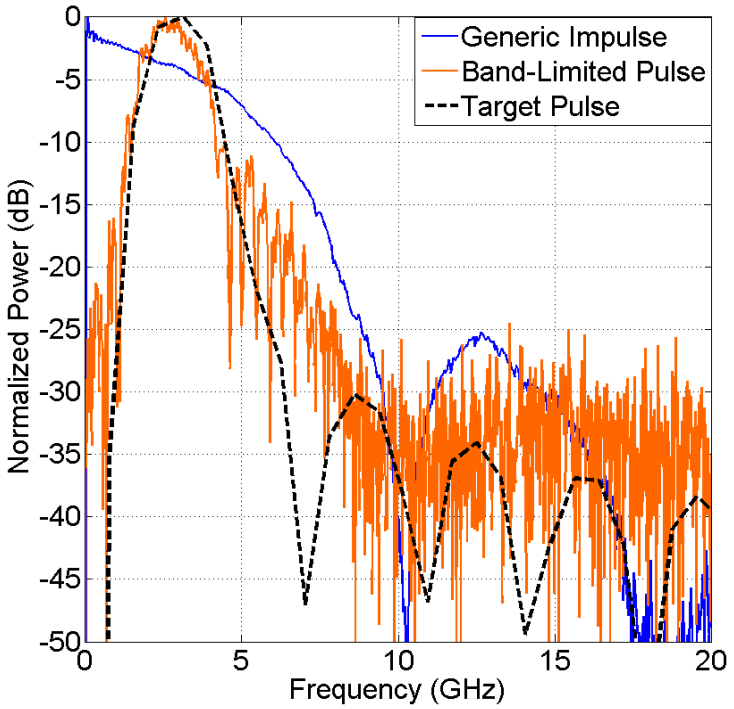


* Oscilloscope
  * Fast sampling oscilloscope
  * 80 GSa/s (12.5 ps sampling period)
  * Controlled by PC

Pulse Shaping

* Generic pulse shaped into 2-4 GHz range using a Synthesized Broadband Reflector (SBR, Santorelli & Schwartz 2013)





Clinical Implementation: Features

* Incorporation of all measurement equipment
* Integrity and repeatability of measurements
* Patient comfort
* Ease of mobility
* Cost-effective
* Easy to sanitize

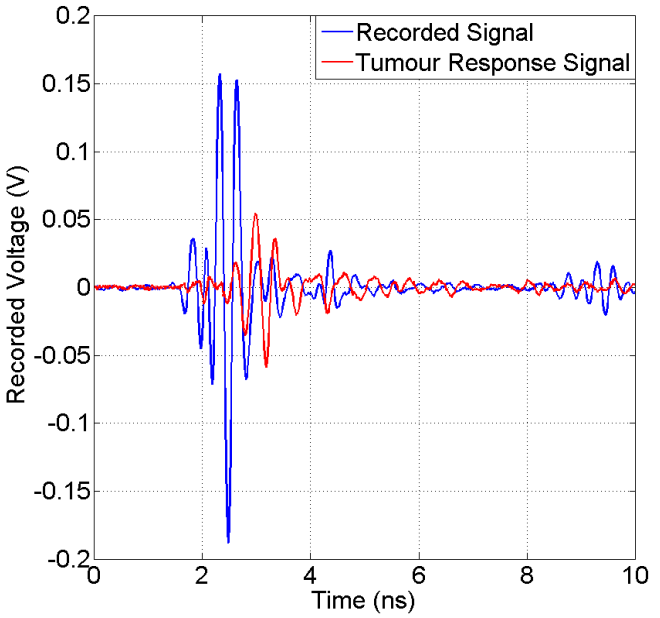
Clinical Trials with Current Prototype

* 15 volunteer participants to be tested with the system
* Examine comfort, ease-of-use, system functionality
* Approved by Health Canada and McGill University

Tumour Detection

* Perform breast scans pre- and post- tumour development
* Tumour response: difference between received signal for healthy baseline and with tumour

* Pre-processing
  * Time-alignment, normalization
  * Remove direct pulse
* Image generation
  * Apply DMAS (delay-multiply and sum)
  * Support Vector Machine



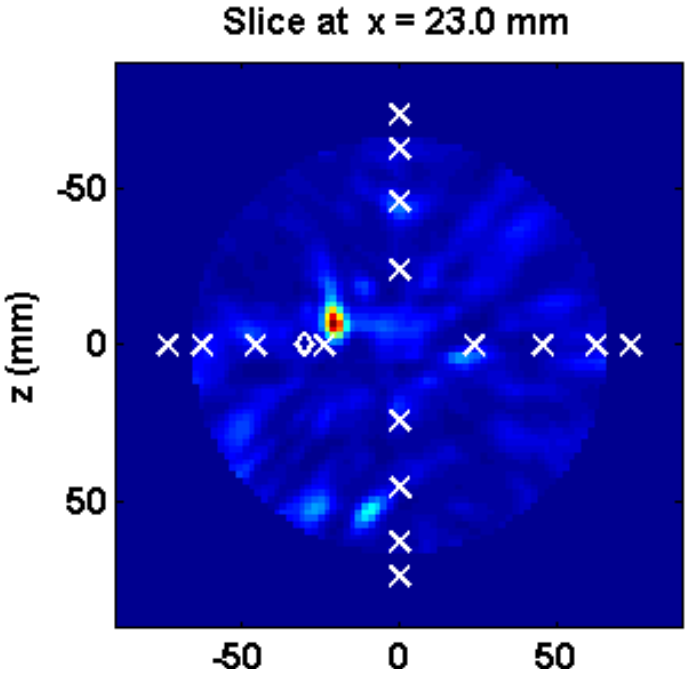
Santorelli, 2013

Sample Results

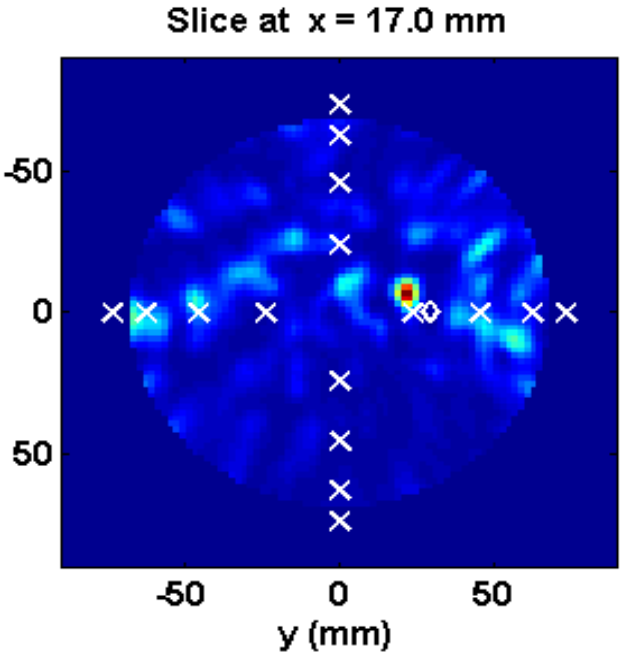
* Tumour detection metrics:
  * Signal to clutter ratio (SCR)
  * Localization error

	SCR (dB)	Error (y, z) (mm)
Example 1	8.2	(9, 7)
Example 2	6.8	(13, 7)

[Porter 2013]



Ex. 1

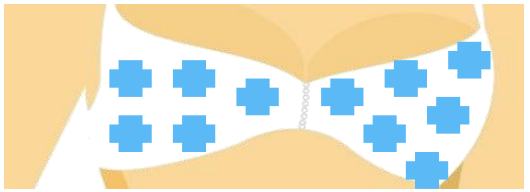


Ex. 2

Future Work

- Must test on patients and compare to images from other modalities
- New antennas
  - Conformable to breast surface: flexible substrate
  - Ultrawideband, broadside radiation (into tissue only)
  - Simple, reliable and repeatable fabrication

- Bra assembly
  - Antenna array ‘woven’ into conforming bra
  - Lightweight, soft fabric with low moisture-absorption
  - Safety: no exposed connections / wires / etc.



Thank you!

* Questions?