Portable MRI Scanner

by

MRI SOLUTIONS

ENSC 305/440 Simon Fraser University

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Team Profile

- **Evangeline Yee, CEO**
  - FPGA programming and Radiofrequency Design
- **Anterpal Singh, CFO**
  - Magnet assembly and Radiofrequency Design
- **Gagandeep Kaur, CCO**
  - Magnet assembly and Radiofrequency Design
- **Barry Yim, CTO**
  - FPGA programming and Analog-to-Digital Converter
- **Robin Wisniewski, CPO**
  - Magnet assembly and Analog-to-Digital Converter

Outline

- Motivation
- Market Research
- Background
- Design Approach
- System Overview
- Challenges
- Design Modifications
- Cost
- Schedule
- Achievements
- Issues
- Team Learning
- Future Work
- Conclusion

Motivation

- MRI is an imaging technique used for various medical diagnosis
- But MRI scanners are very expensive
- Average wait time is 12 to 18 months[1]
- Only 6 MRI scanners per million population in Canada[1]

Market Research

MRI Model	Cost	Picture	Details
GE Signa HDxt 3.0T	$3,000,000	 [2]	3.0 Tesla Field strength Superconducting magnet 6.31 m² footprint
Philips Panorama 0.23T	$300,000+	 [3]	0.23 Tesla field strength Resistive magnet 2.13 m² footprint

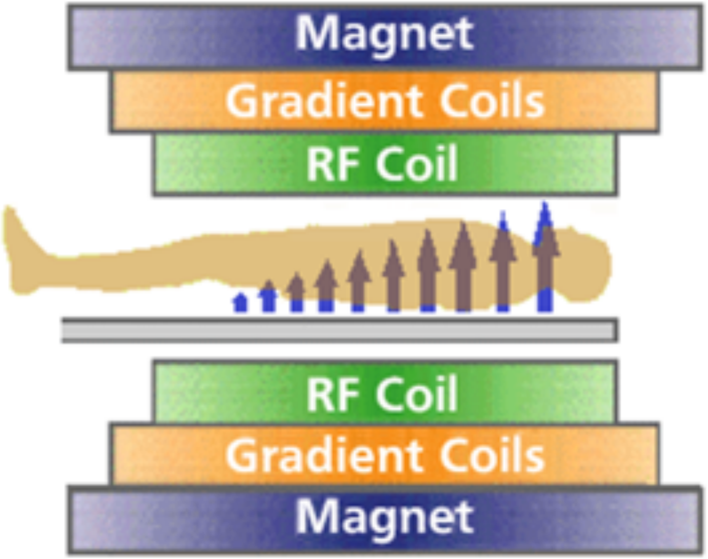
Background

[4]

https://www.youtube.com/watch?v=1CGzk-nV06gMRI

Design Approach

Conventional Design

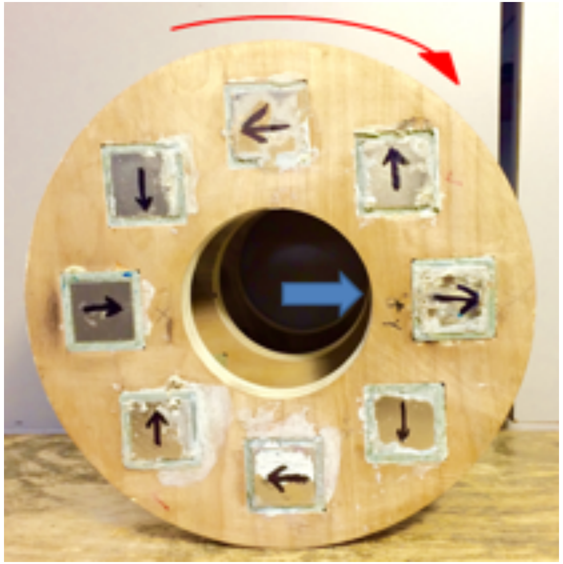


[5]

- Fourier imaging
- Linear gradient field
- Superconducting magnet
- Gradient coils
- Expensive

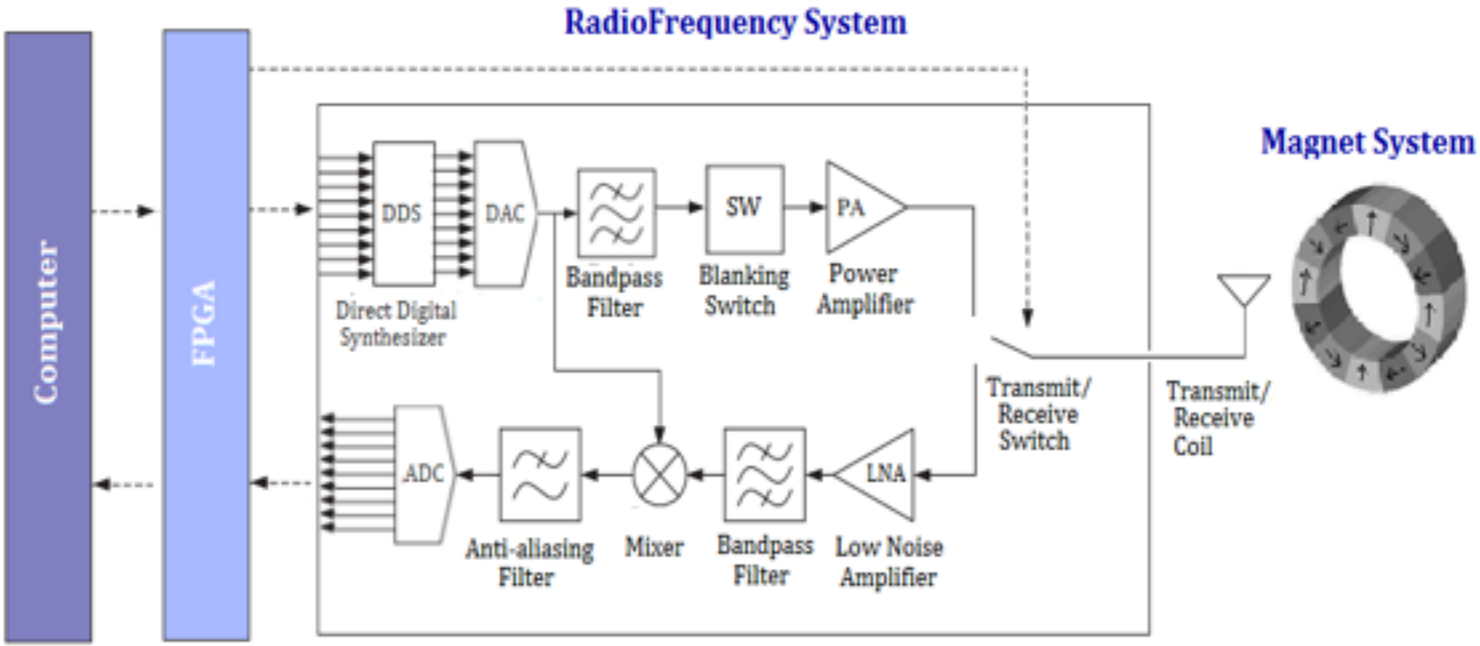
Design Approach

Our Design

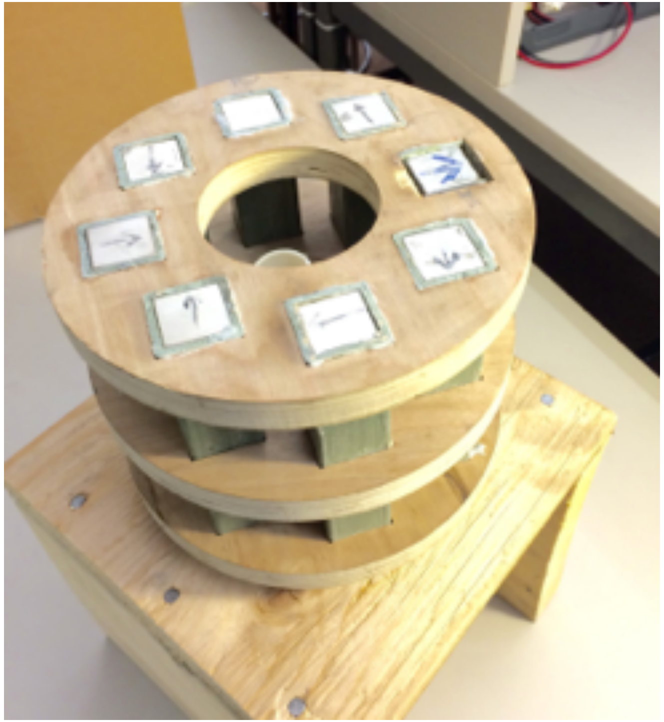


- Projection-based imaging [6]
- Rotating magnetic field
- Permanent magnets
- No gradient coils
- Cost-effective
- Portable

System Overview

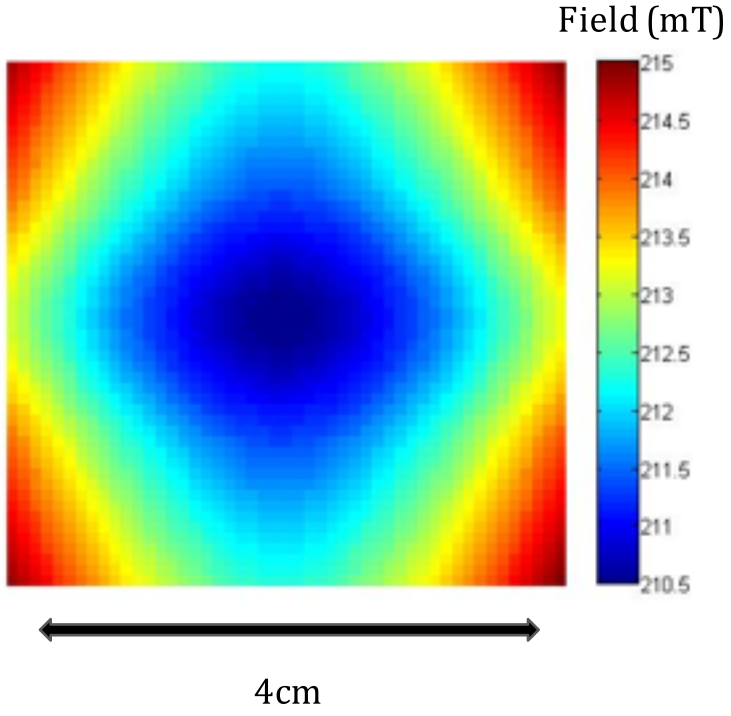


Magnet System



- Halbach design
  - 24 Neodymium magnets
- Fiberglass housing
- Waterjet-cut plywood housing
- Swivel plate

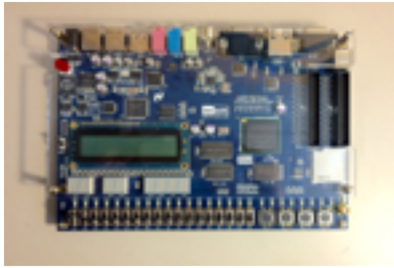
Field Mapping



- AD22151 field sensor with Arduino Uno
- 0.21 T field strength
- 0.5 % inhomogeneity in 1 cm diameter sphere

Radiofrequency System

Transmission Chain



FPGA

DDS

Low Pass Filter

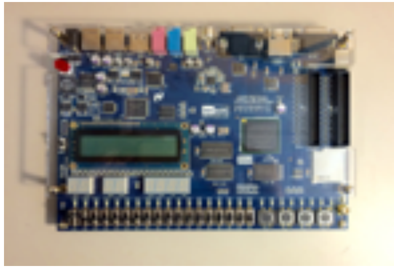
Transmitting Coil

Power Amplifier

Blanking switch

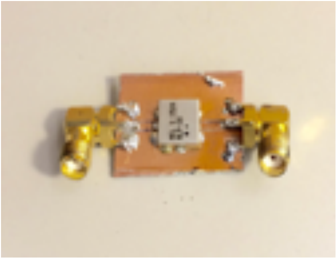
Radiofrequency System

Transmission Chain



FPGA

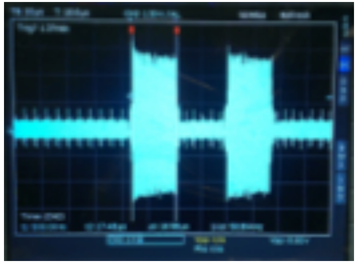
DDS



Low Pass Filter

Transmitting Coil

Power Amplifier

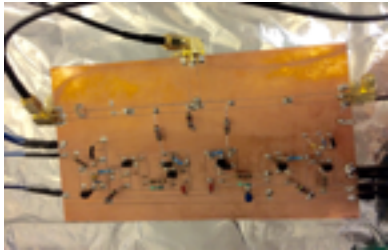


Blanking switch

Radiofrequency System

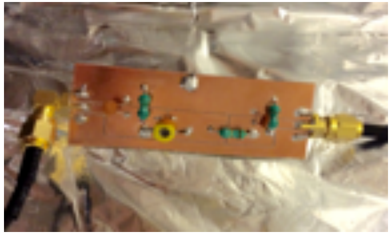
Receiving Chain

Receiving coil



T/R Switch

Low noise amplifier



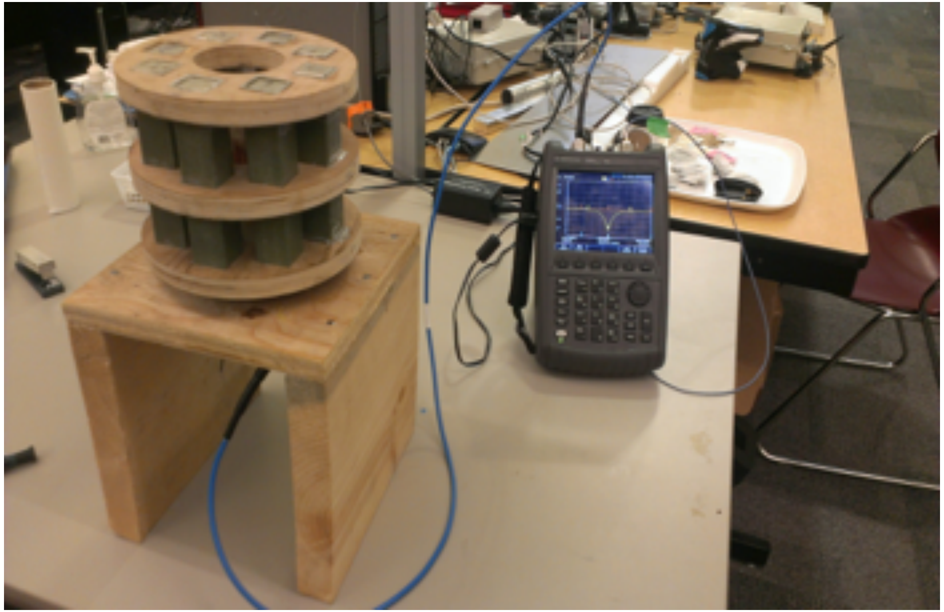
Bandpass Filter

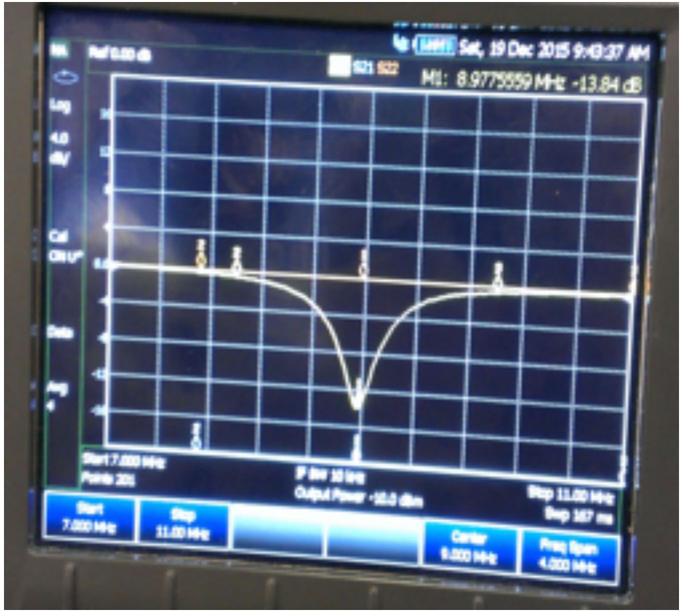
Challenges

- High Frequency Electronics
- Maximum Power transfer at 50 ohm
- Matching and tuning circuit
    - Lack of proper test equipment
    - Innovative method for measurement
    - Requested network analyzer

Challenges

Network Analyzer- SW Communications Laboratory

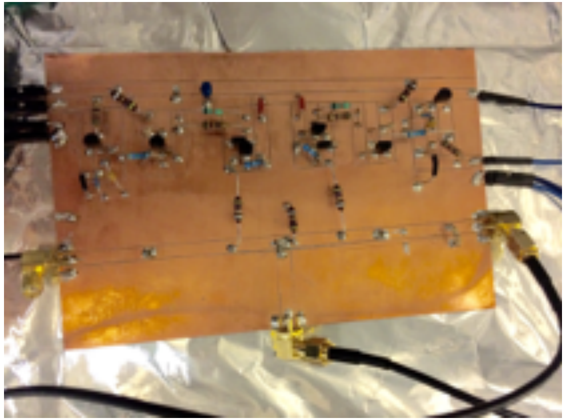




Challenges

- T/R Switch
  - Protect low noise amplifier during transmission
  - Available T/R switch either rated for low power or for very high frequency
  - 3 revisions based on papers
  - Good isolation for voltages below 15 V
  - Low noise amplifier saturation improved

- Noise
  - Response signal is very weak
  - 50 mV noise level



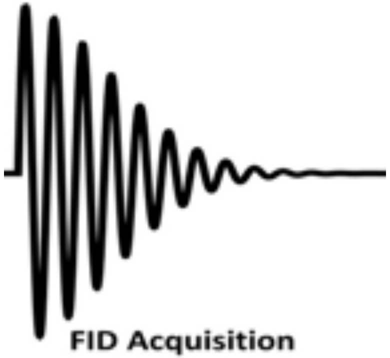
T/R Switch

Change in Scope

- Original goal was 2D Imaging
- Algebraic Back Projection- Kaczmarz
  - 1D signal
  - Controlled rotation

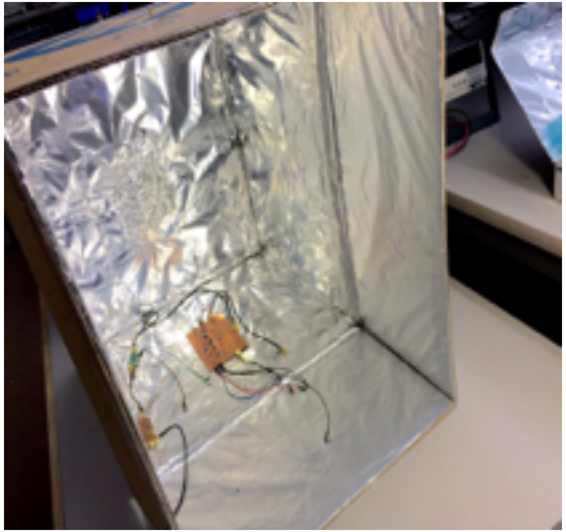
[6]

- Revised goal is to observe 1D signal



Design Modifications

- Separate Transmitting and Receiving coils
  - Increase signal strength
  - Orthogonal to minimize coupling
  - Prevents Low noise amplifier from saturating
- Faraday's Cage
  - Minimize noise
- Signal averaging
  - Collected data from Oscilloscope
  - Averaged data for various trials
  - Improves signal-to-noise ratio



Faraday cage

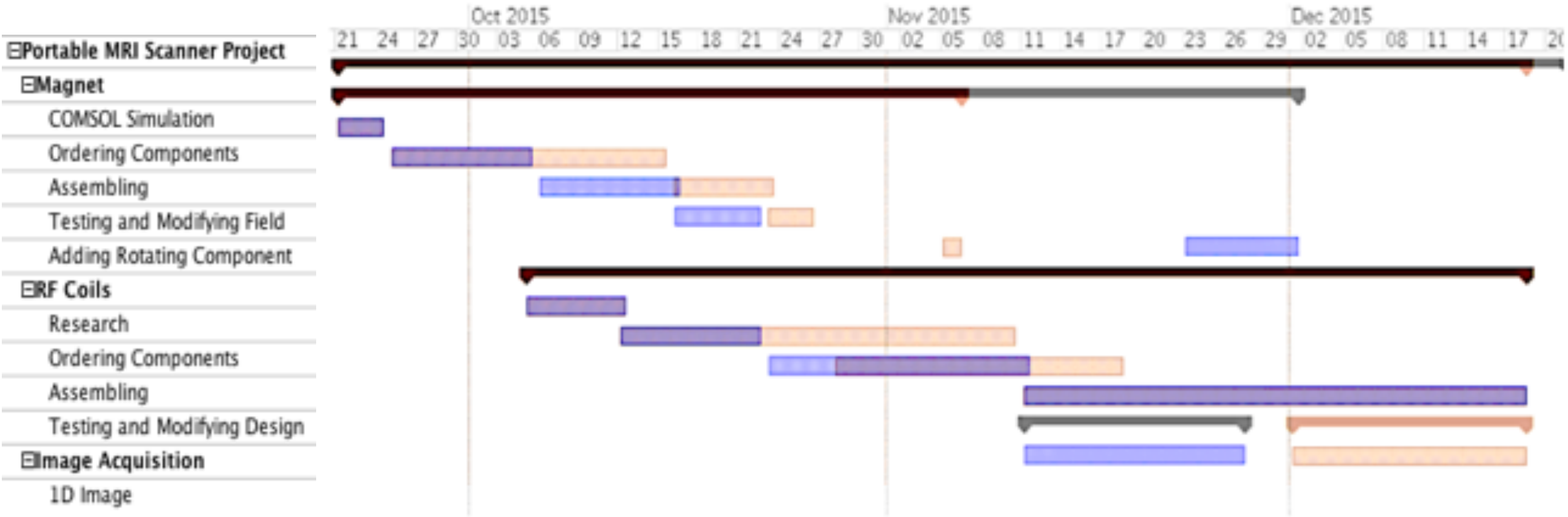
Cost

Equipment	Estimated Cost ($)	Actual Cost ($)
Magnet System	$810.00	$819.34
Transmitting System	$250.00	$334.13
Receiving System	$110.00	$285.27
Contingency (20%)/Miscellaneous	$234.00	$264.60
Total	**$1404.00**	**$1703.34**

Schedule

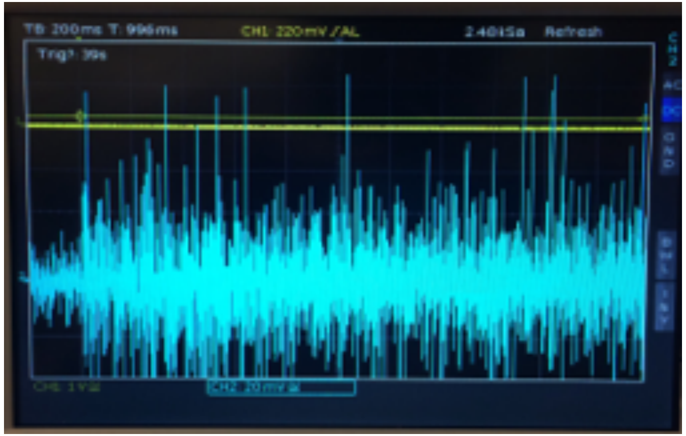
Proposed Schedule

Actual Schedule



Achievements

- Individual components operate as expected
- Integration is functioning as expected
- Acquired data at various frequencies, pulse length and amplitude



Response

Issues & Future Work

- Issues
  - Response signal is possibly too small to process
  - The sample has changed the field or tuning considerably
- Future Work
  - Improve system for 1D imaging
  - Rotation System for projection based imaging

Team Learning

- High frequency design
- Prototyping on copper clad and protoboards
- Innovative solutions for testing in the absence of appropriate instruments
- Time management
- Communication
- Proper documentation

Conclusion

- Built and tested our Magnet and Radiofrequency systems
- Ran over 200 trials and performed Signal Averaging
- Not able to observe 1D response
- But learned a lot by attempting to build an unconventional MRI

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References

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[2] *GE Signa HDxt 3.0T*. 2015.

[3] *Philips Panorama 0.23T. 2015*

[4] YouTube, "How Does an MRI Work?", 2015. [Online]. Available: https://www.youtube.com/watch?v=1CGzk-nV06g. [Accessed: 21- Dec- 2015].

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Questions?