Simulation Studies of a Radio Frequency Penetrable PET Insert for Simultaneous PET/MR Imaging

Molecular Imaging Program at Stanford

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INTRODUCTION

Positron Emission Tomography (PET)

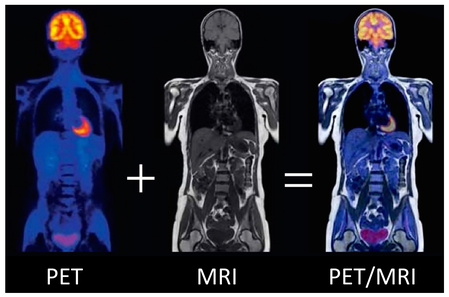
- detects gamma rays given off by a positron-emitting radionuclide tracer that is introduced into the body
- provides functional information about organs and tissues

Magnetic Resonance Imaging (MRI)

- uses magnetic fields and radio waves
- provides anatomical information about organs, soft tissues, and bones

Simultaneous PET/MR Imaging

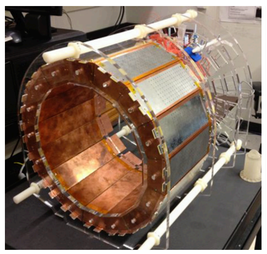
- combines functional and anatomical information from both imaging modalities
- anatomical localization of PET data improves image registration



PET, MRI, and combined PET/MRI images of the body.[1]

OBJECTIVES

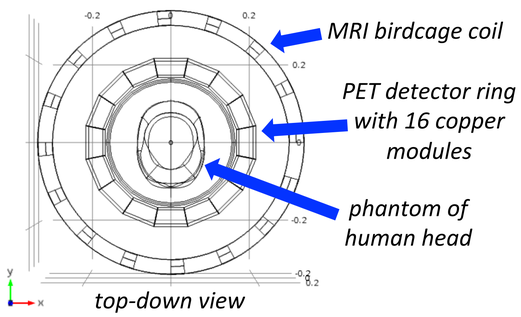
- study radio frequency (RF) interactions around the gaps of a PET insert designed for simultaneous PET/MR imaging of the brain, via COMSOL simulations
- evaluate RF penetrability of the PET insert, to validate usage of the built-in RF body coil, without requiring an additional RF transmit/receive coil

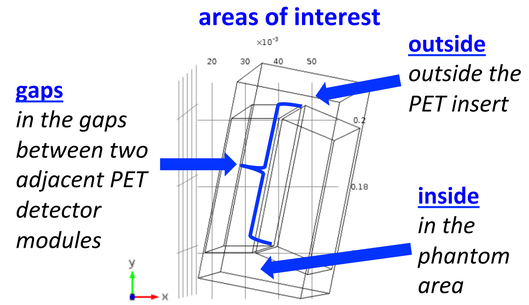


PET insert prototype with 16 detector modules.[2]

PET insert prototype advancing into MRI machine bore.[2]

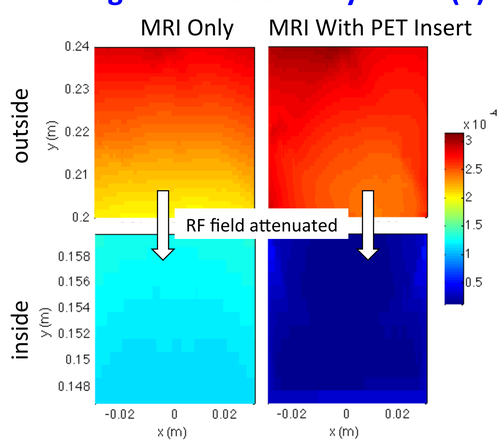
MODELING THE PET/MR SYSTEM

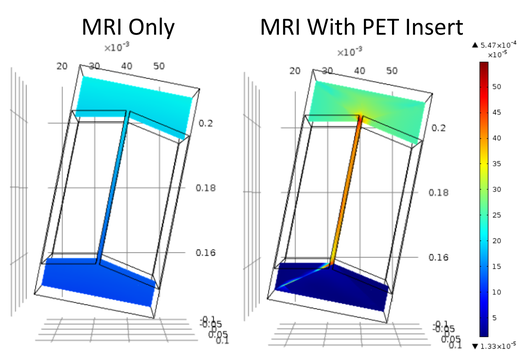




RESULTS

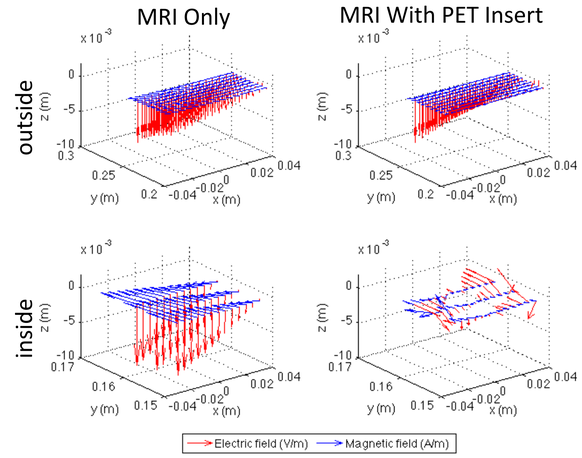
Magnetic Flux Density Norm (T)

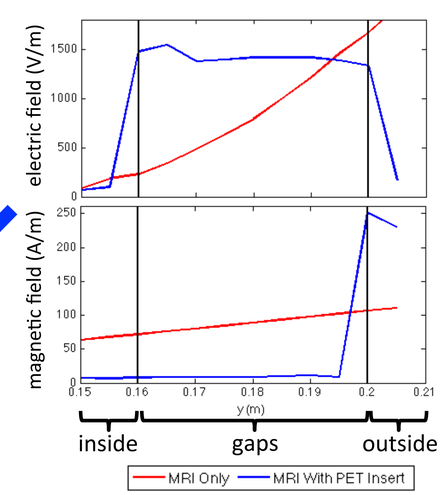




		inside	gaps	outside
average electric field (V/m)	MRI Only	136.52	768.25	1802.19
	PET/MRI	85.08	1428.39	750.20
average magnetic field (A/m)	MRI Only	65.49	86.85	108.71
	PET/MRI	7.21	9.05	241.02

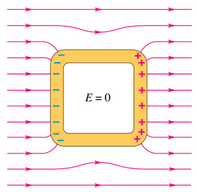
Electromagnetic (EM) Fields



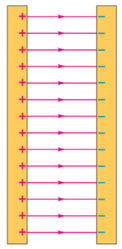


DISCUSSION

- The RF field is attenuated upon passing between detectors and into the phantom area.
- Each copper PET module acts as a Faraday cage, disrupting the paths of EM fields and forcing EM waves to travel between and around detectors[3].



- Wave scattering at the dielectric-conductor interface between air and the surface of copper PET modules induce EM waves reflection and refraction at varying angles.
- The sides of two adjacent PET detector modules act like capacitors[4]. Because the conductive surfaces of all modules are at the same voltage, capacitive dissipation and Gauss's law explain the approximately constant electric field between detector modules along the length of each gap.



CONCLUSION

Physics simulations comparing a combined PET/MR imaging system with only MRI characterized RF fields passing through an added PET insert. Because this PET insert is proven to be RF penetrable, the RF body coil of the MRI machine can be used for simultaneous PET/MRI imaging, without the need for a separate coil to transmit RF.

FUTURE WORK

RF field behavior, especially at the boundaries of the PET insert, will be further investigated. Results will be used to further improve the PET insert prototype towards eventually developing a full-body PET/MR system that can be implemented clinically.

Acknowledgements

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Selected References

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