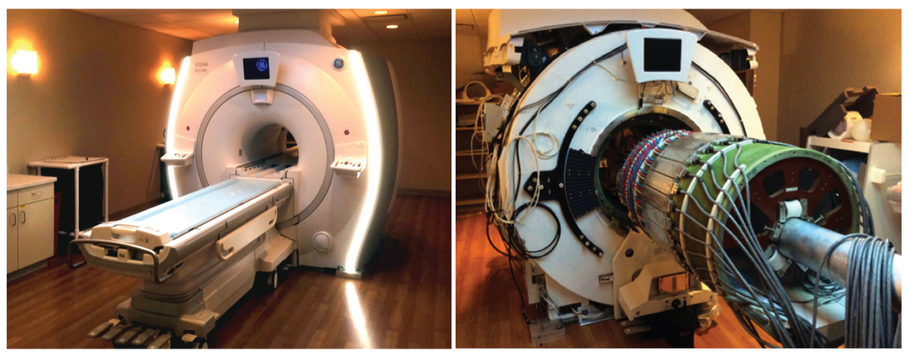
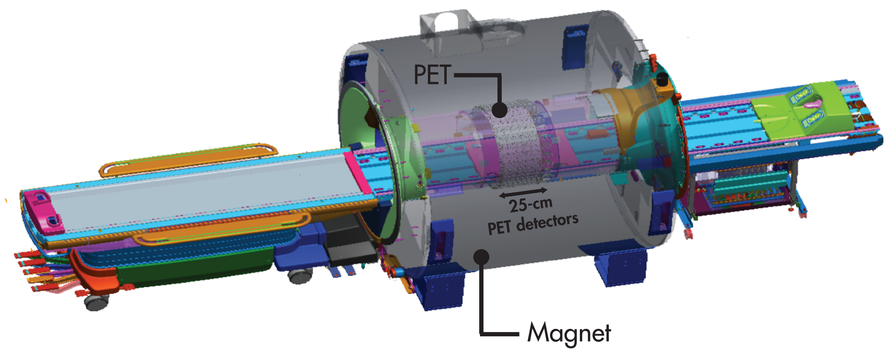
THE EFFECT OF MAGNETIC FIELD ON POSITRON RANGE AND SPATIAL RESOLUTION IN AN INTEGRATED WHOLE-BODY TIME-OF-FLIGHT PET/MRI SYSTEM

Shih-ying Huang, Dragana Savic, Jaewon Yang, Uttam Shrestha, Youngho Seo, *Senior Member IEEE*
UCSF Physics Research Laboratory, Department of Radiology and Biomedical Imaging, University of California, San Francisco

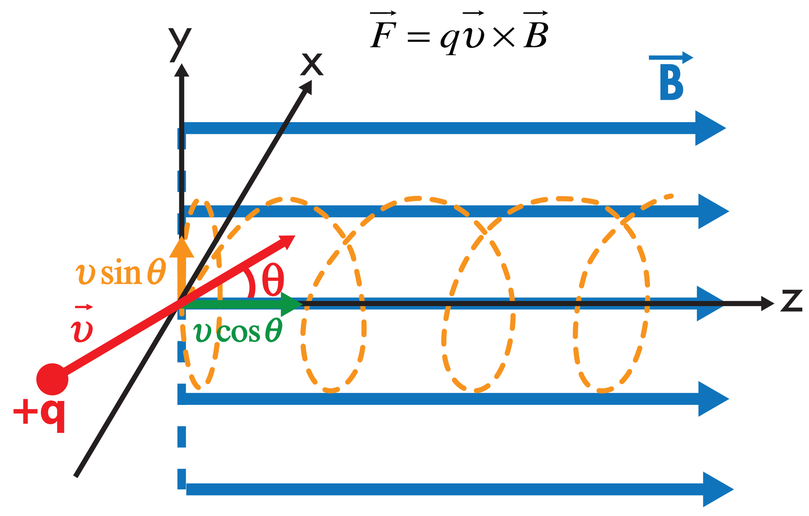
INTEGRATED PET/MRI SYSTEM



GE Investigational PET/MR



A CHARGED PARTICLE MOVING THROUGH A MAGNETIC FIELD

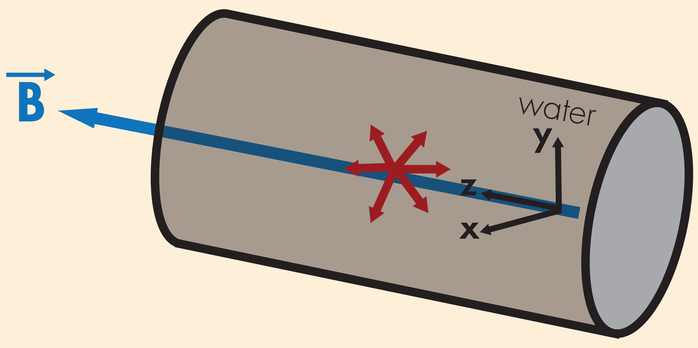


Force parallel to the magnetic field: $F_{//} = 0$

Force not parallel to the magnetic field: $F = qv\sin\theta$

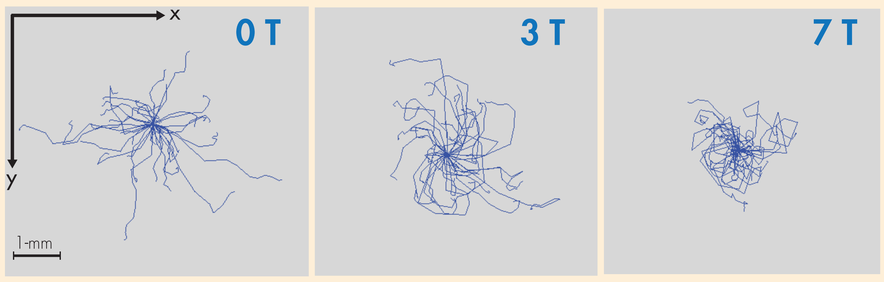
QUESTION: Does the magnetic field affect the PET/MRI system spatial resolution for long-range positron emitters?

GEANT4 MONTE CARLO SIMULATIONS

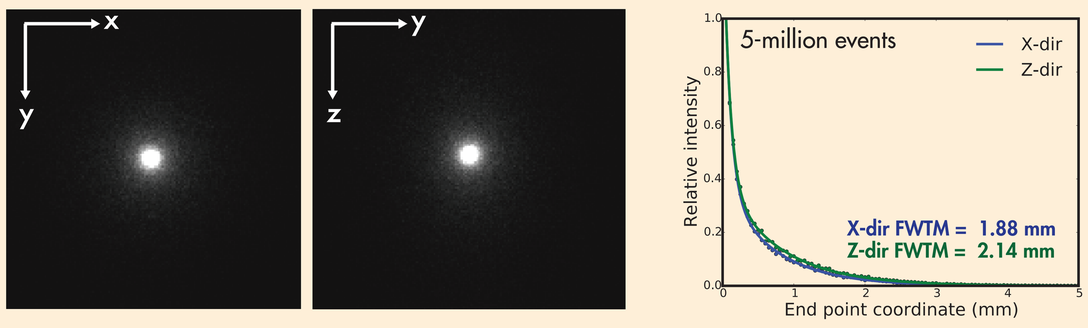


- GEANT4 Monte Carlo simulation version 4.9.6.p02
- Applied uniform magnetic field in the z-dir of a water cylinder
- Isotropic distribution of ^{18}F, ^{124}I, and ^{68}Ga
- Recorded positron annihilation position
- Fitted the positron spread profile with bi-exponential function
- Evaluate full-width at tenth maximum (FWTM) of the point spread function

GEANT4 Simulated Positron Track of ^{68}Ga in Water



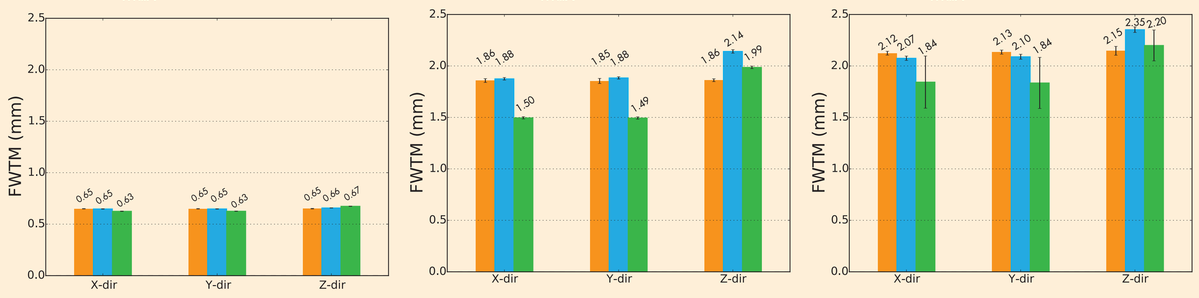
^{68}Ga Point Spread Profile with 3 T Magnetic Field in Water



Positron range vs. Magnetic field

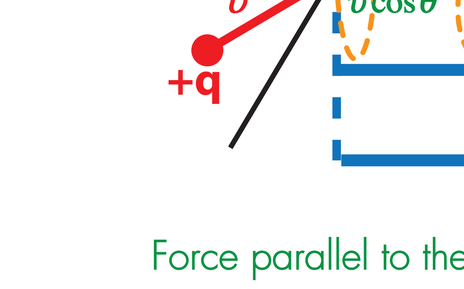
0 T 3 T 7 T

^{18}F (E_{max} = 633.5 keV) ^{68}Ga (E_{max} = 1.89 MeV) ^{124}I (E_{max} = 2.14 MeV)



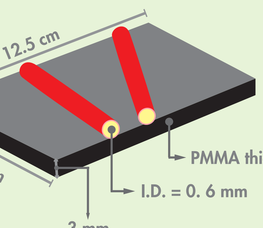
EXPERIMENTAL IMAGING

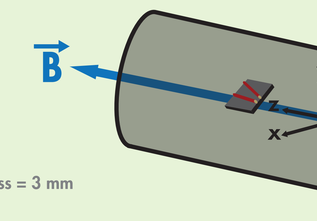
Image the line source phantom in the PET/CT and PET/MRI systems



	GE Investigational PET/MR (3 T)	GE PET/CT Discovery VCT
PET Crystal Size		
In-plane (mm)	3.95	4.7
Axial (mm)	5.3	6.3
PET Detector Ring Diameter (cm)	60	88
3D PET Acquisition (min per bed/# of bed)	3.0 / 1 bed	5.0 / 1 bed
PET Reconstruction Method (GE research toolbox)	3D Fourier-rebinned filtered backprojection	3D Fourier-rebinned filtered backprojection
PET Reconstructed Image Voxel Size (mm^3)	1.37 x 1.37 x 2.78	1.37 x 1.37 x 3.27

Image Analysis Workflow

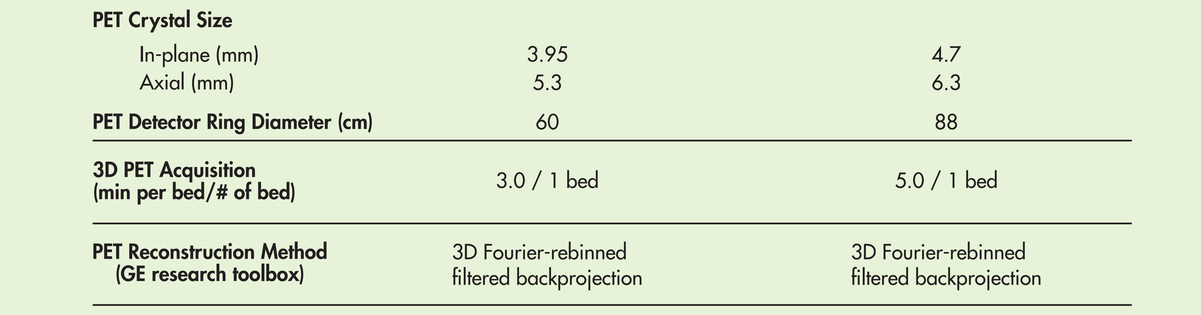




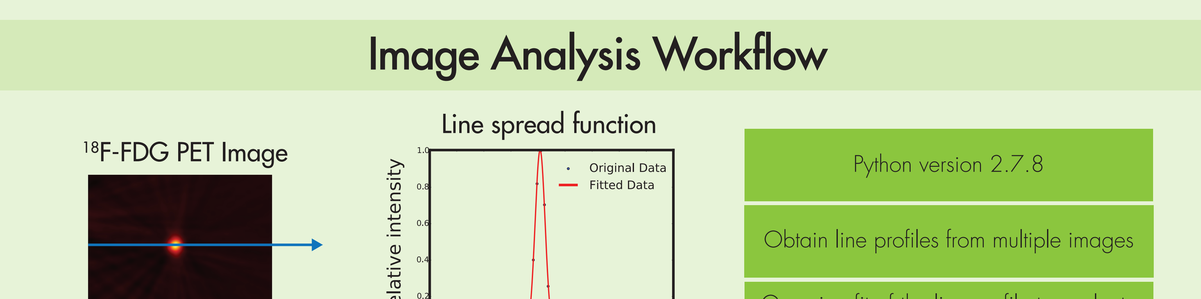
- Python version 2.7.8
- Obtain line profiles from multiple images
- Gaussian fit of the line profile to evaluate full-width at half maximum (FWHM)

Line source in Air

PET/CT (0 T) PET/MRI (3 T)



Line source in Water



What did the simulations tell us?

- The magnetic field may reduce in-plane positron spread but slightly increase positron spread in the direction of the magnetic field
- The effect of magnetic field on positron spread is more noticeable for long-range positron emitters such as ^{68}Ga, ^{124}I, and ^{82}Rb

What did the phantom imaging show?

- The ratio of $FWHM_z$ to $FWHM_{Avg(x,y)}$ suggests a small effect on system spatial resolution from the magnetic field for ^{68}Ga
- The 3 T magnetic field has nonsignificant effect on PET/MRI system spatial resolution

ACKNOWLEDGMENTS

- Tremendous help from Vahid Ravanfart (nuclear medicine technologist) for phantom imaging
- Helpful conversation with the GE research team

This work is supported by:
- GE Healthcare
- National Cancer Institute R01 CA154561