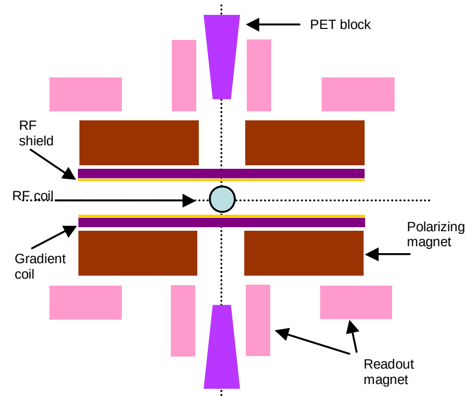
Evaluation of PET detector operation in field-cycled MRI

H. Peng[1], W. H. Handler[1], T. J. Scholl[1], P. J. Simpson[1], B. A. Chronik[1]
[1]Physics and Astronomy, University of Western Ontario, London, Ontario, Canada

Introduction: The feasibility of integrating a resistive, field cycled MRI system [1-2] with positron emission tomography (PET) has been studied for the first time. Integrating MRI/PET into the same scanner would allow high-resolution anatomical information from MRI to be directly merged with functional images attainable with PET [3]. The possibility of designing a field cycled MR system in an open geometry would allow a PET ring to be placed in an annulus around the imaging volume while introducing a minimum of material to cause gamma ray scattering (see Fig. 1, top). The proposed idea is to operate the two modalities in an interleaved fashion, with the PET system operational only during the period when the field cycled magnets are completely off (see Fig. 2, top). The primary question addressed in this abstract is how traditional photomultiplier tube (PMT) PET detectors respond to both static and dynamic magnetic fields. A traditional PET detection scheme is considered because of its technological maturity and cost effectiveness. Of particular importance is the recovery time of a traditional PMT following a strong magnetic field pulse.



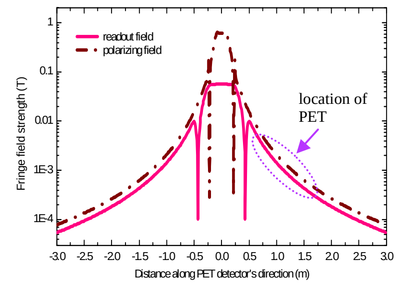


Figure.1 top: cross-section diagram of open field cycled MRI system. bottom: the fringe field strength along PET detector's direction in our prototype design

Methods: Two types of PMTs (Hamamatsu H1161 (Linear) and Bicron EF844 (Box & Grid)) were tested, each with a NaI scintillator and Mu-metal shielding. The detector gain, energy resolution and timing resolution for detection of 511 KeV gamma rays were first measured as a function of static magnetic field strength. A switching magnetic field of 5 T/s (5 mT change over 1 ms) was generated using parallel IGBT circuits [4]. The recovery of PMT detector performance following these pulses, simulating the MRI system operation, was characterized. Gain and energy resolution were measured as a function of time after the magnetic field pulse.

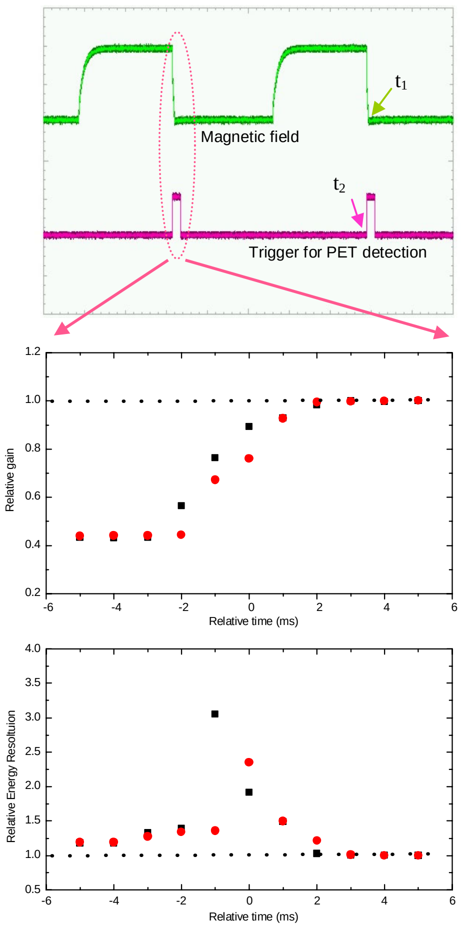


Figure.2 top: Data acquisition sequence for field cycled MRI and PET system. center: relative gain recovery process for two PMTs. bottom: relative resolution recovery process for two PMTs. (relative time represents t_2-t_1. circle: Hamamatsu square: Bicron)

Results: Detector energy resolution of 11.4% (7.3%), and time resolution of 20.0 ns (8.3 ns) were found for the Bicron PMT in a static magnetic field of 50 gauss (the values without magnetic field are in brackets). These values are slightly better than the 13.6% (10.5%) and 25 ns (8.7 ns) obtained for the Hamamatsu PMT. We attribute this to the difference in the PMT structure. All these values are comparable to results reported by others using various MRI/PET detection methods [5-6]. We found that the PMTs' performances recover completely within 2-3 ms and remain stable after the magnetic field cycles to zero. (shown in Fig.2)

Discussion: Due to the rapid recovery of PMT performance following a magnetic field pulse, an interleaved MRI/PET system appears to be possible. Simultaneous MRI/PET detection may also be possible since the PET detectors are not in the region of maximum magnetic field, and this technique may provide better temporal correlation; however, further investigations on how to correct for the differences in detector behavior during the magnetic field exposure period are necessary. Further investigations using higher fields, and investigations of magnetic field effects on the positioning accuracy of clinically used Anger logic PET cameras are also ongoing.

References:
[1] P. Morgan, et al, Magnetic Resonance in Medicine, 36, 527-536 (1996).
[2] A. Macovsk et al, Magnetic Resonance in Medicine, 30, 221-230 (1993).
[3] B.E. Hammer, Physics Medica, Vol XII. Supplement1, 69-76 June 1996.
[4] S.M. Conolly, et al, Proc. ISMRM, p473 (1999).
[5] Y. Shao, et al, Phys. Med. Biol, 42, 1965-1970 (1997).
[6] N.L. Christensen, et al, Phys. Med. Biol, 40, 691-697 (1995).