Novel Split Coil Imaging Magnet

Dr. R. E. Ansorge[1], Dr. T. A. Carpenter.[2], Dr. N. R. Shaw[1]

[1]University of Cambridge, Department of Physics, Cavendish Laboratory, Madingley Road, Cambridge CB3 0HE, UK;
[2]University of Cambridge, Clinical School, Wolfson Brain Imaging Center, Box 65, Addenbrooke's Hospital, Hills Road, Cambridge CB2 2QQ, UK.

A novel 1T split coil MRI magnet has been designed and built. The self shielded superconducting magnet has been designed with an 8 cm room temperature gap and is suitable for true simultaneous MRI and PET image acquisition. Recently combined PET/CT scanners have been introduced for clinical work [1]. These systems allow for a CT scan to be followed be a PET scan; the patient bed being moved between two imaging stations. In contrast a combined PET/MRI scanner is potentially capable of true simultaneous image acquisition for considerable periods of time. A combined PET/MRI scanner provides complimentary data about structure and function and thus has an important role in both clinical and small animal imaging. In addition continuous MRI acquisitions permit monitoring and correction of motion blurring during relatively long PET acquisitions. Molecular Imaging [2] is seen as a particularly important application of the system. Previous attempts at combined PET/MRI [3] have used standard clinical MRI magnets with relatively crude PET detectors placed inside. In contrast the present instrument will incorporate a full microPET [4] system in a bespoke MRI magnet. The 1T field will give an MRI resolution down to 0.2 x 0.2 x 0.2 mm, more than adequate for registration of the PET data. The magnet was manufactured by Magnex Scientific [5] to a special design [6]. The magnet was installed in October 2003 in the University Department of Physics.

Summary of Magnet design	
Central Field	1T
Fringe Field	50 mT at 1.25m, 0.5 mT at 3.2m
Spherical ROI	8 cm (1ppm uniformity)
Cooling	He and N_2 cryostats
Warm Bore	35 cm diameter, 8 cm gap
MRI resolution	0.2 x 0.2 x 0.2 mm
PET resolution	1.0 x 1.0 x 1.5 mm

The uniformity of the 8 cm spherical ROI has been verified to be less than 1ppm after shimming. A key feature of the design is that light from the LSO crystal PET detectors is brought to position sensitive PMTs in a low (< 50mT) magnetic field region using ~1m long light guides. Moreover the axial symmetry of the design minimises the effects of magnetic field perturbation from magnetic elements in the detector. The open design of the magnet means that it can also be used for simultaneous MRI imaging with other modalities, for example optical tomography or fluorescence.

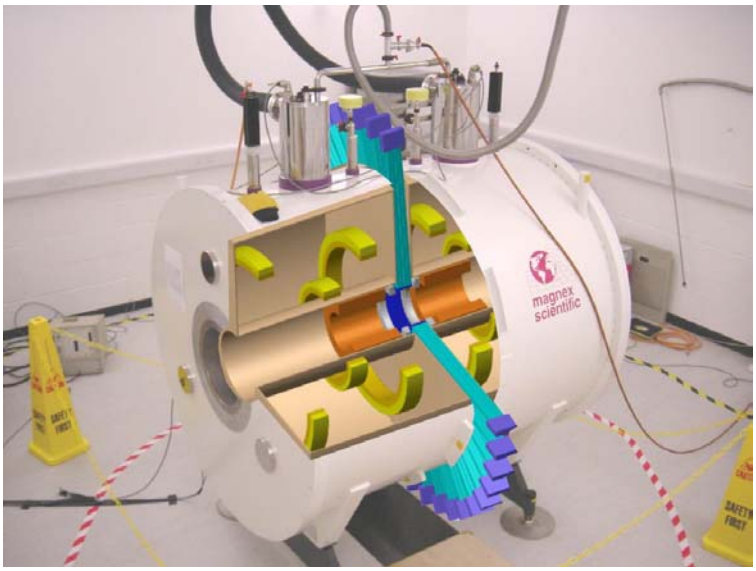

Fig 1: Montage showing installed Split Coil Magnet and superimposed graphic of coils and proposed PET ring. The PET detector will consist of 170 sets of 64 2x2x10 mm LSO crystals connected via ~1m long light guides to position sensitive PMTs. The 10 mT (red) and 0.5 mT (yellow) contours are visible on the floor.

References:

1. T.F. Hany et. al., *"PET Diagnostic Accuracy: Improvement with In-Line PET-CT System: Initial Results,"* Radiology 225, 575–581, (2002).
2. M.E. Phelps, *"Positron emission tomography provides molecular imaging of biological processes",* Proc Natl Acad Sci USA 97, 9226-33, (2000).
3. Y. Shao, S.R. Cherry et. al., *"Development of a PET detector system compatible with MRI/NMR systems,"* IEEE Trans on Nucl Sci 44, 1167-1171, (1997).
4. S.R. Cherry, Shao Y., et al., *"MicroPET: a high resolution PET scanner for imaging small animals,"* IEEE Trans on Nuclear *Science* 44, 1161-1166, (1997).
5. Magnex Scientific Ltd. 6 Mead Road, Oxford Industrial Park, Yarnton OX5 1QU, UK.
6. R.E. Ansorge and N.R. Shaw, *"Genetic Algorithms for MRI Magnet Design,"* IEEE Trans on Applied Superconductivity, 12, 733-736, (2002).

Acknowledgements: UK EPSRC and MRC research councils.