Investigation of PET count rate reduction during EPI scan on an MR-PET hybrid system

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Abstract

Hybrid MR-PET scanners offer great opportunities for the investigation of scientific questions and clinical diagnoses that are related to metabolism as well as function and structure of the brain. However, since the technology is new and still in development, it is of great importance to investigate how MR and PET systems influence each other in a combined scanner. Here, the effect of switched magnetic field gradients on the PET count rate is demonstrated and investigated.

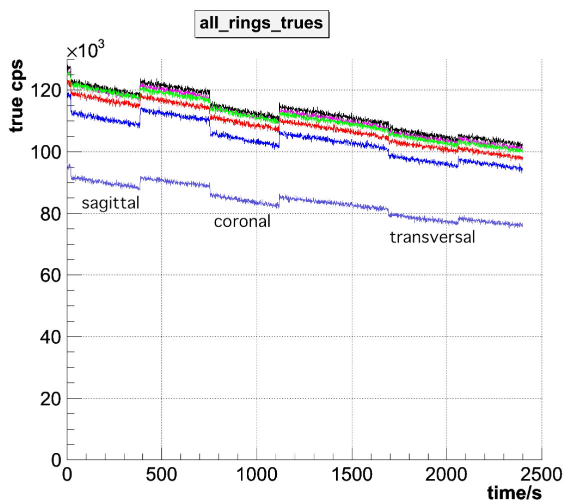
Introduction

The combination of PET and MR scanners in a single, hybrid system is a promising but demanding new technology. Whereas positron emission tomography (PET) offers high metabolic specificity, MRI is provides superior spatial resolution and can deliver a huge variety of contrast mechanisms including functional imaging. However, the implementation of a PET system inside the magnetic field of an MR scanner is challenging. Although the newly developed PET detector consists of components which are insensitive to strong magnetic fields, there might be residual interferences caused by the magnetic field gradients and the radiofrequency pulses that are used to excite during the MRI scan. It is a well-known problem in MRI that gradient ramping cause eddy currents which can result in image artefacts [1-3]. Eddy currents may also influence the electronics of a PET ring operating in the bore of an MR scanner. This work examines possible changes of the PET count rate and their dependence on the gradient field orientation with respect to the PET ring.

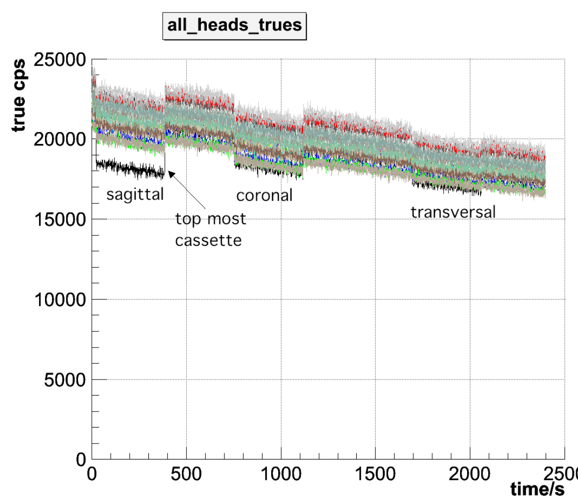
Methods

A combined MR-PET scan was performed on a Siemens 3 Tesla MAGNETOM Tim-Trio system equipped with a BrainPET insert. This hybrid scanner comprises a new magneto-insensitive APD-based PET detector in a commercial 3T MRI scanner [4,5]. The BrainPET consists of 32 cassettes, each encased in a thin copper layer, which shields against the radiofrequency from the MRI scanner. Six compact block modules measuring 33 x 33 x 63 mm^3 are lined up in one cassette. The front-end of the detector has 12 x 12 LSO crystals, each of 2.5 x 2.5 x 20 mm^3, which are read out by an array of 3 x 3 APDs. Each cassette is linked by a 10 m long cable to the filter plate of the MRI cabin, the exterior of which is attached to a modified version of the QuickSilver data acquisition electronics [6]. The BrainPET insert has an outer radius of 60 cm fitting into the bore of the magnet and an inner radius of 32 cm for the MR radio frequency head coil. The axial length of the PET FOV ring is 20 cm. The MR coils used were an eight-channel phased array receive and a birdcage transmit coil. A cylindrical phantom of 20 cm height and 15 cm diameter was filled with 3.75g NiSO4 x 6 H2O + 5g NaCl per 1000g H2O. 50 MBq of ^{18}F radioactivity was injected in the phantom. PET was performed for 40 min. Three EPI scans of different slice, read out and phase encode orientation were performed ***simultaneously*** (see table). The EPI sequence had an echo time, TE, of 30 ms and a repetition time, TR, of 2 sec. EPI imaging was performed in each orientation for 6 min.

orientation (slice select)	phase	read	time [sec]
sagittal	A>>P	F>>H	20-380
coronal	F>>H	R>>L	750-1110
transversal	R>>L	A>>P	1700-2060



A)



B)

Results

PET true event count rates are plotted separately for the 6 rings as well as the 32 to cassettes of the BrainPET system in A) and B), respectively. Each of the three EPI scans reduces the PET count rate. The last EPI scan in transverse orientation shows the lowest effect with a count rate reduction of about 1.6% (figure A). For transverse orientation read and phase encode gradients are in plane of the PET ring. For the other two orientations read or phase encode were in foot-to-head (F>>H) orientation and perpendicular to the PET ring. Here, the count rate reduction was 3.3% (figure A). The upper most cassette shows a even higher reduction for sagittal slice orientation.

The most gradient ramping is performed by readout and phase encode gradients during EPI readout. Therefore, these gradients also are capable of causing the most eddy currents in the structure of the PET ring. Since the lowest effect is investigated for transverse slice orientation it can be concluded that gradient-induced eddy currents are responsible for the count rate reduction. The reason for the high count rate reduction in the upper most cassette for sagittal orientation is not clear. It may related to some deviation of its electronic components.

Conclusions

A clear influence of magnetic field gradient ramping on the PET hardware was demonstrated. In general the effect is small especially for transverse slice orientation. From gradient orientation dependence, it can be concluded that the count rate reduction is caused by eddy currents. However, the effect of eddy currents inside the PET electronics needs further investigation.

References

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