Novel Gradient Transparent RF Shielding Technologies for integrated PET/MR

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Purpose
Integration of Positron Emission Tomography (PET) and Magnetic Resonance (MR) in a combined device is a promising hybrid imaging modality for diagnosis and research in medicine. In these devices, the PET detectors are located within the large static and dynamic magnetic fields of the MR. Electromagnetic radiation emitted by the PET detector electronics influences the MR device. This makes a suitable shielding enclosure necessary. The shielding should ideally be transparent for the MR gradient fields while efficiently blocking the broadband electromagnetic emission from the PET detector electronics. This is usually done by using thin layers of conducting material. We investigated the effect of a multiple shell screening setup as compared to a single shell.

Methods
Spherical shells of conducting material were used as a simple model for the PET detector module shielding. Maxwell's equations had been solved for the case of quasi-static magnetic fields and the results were compared to a numerical simulation with a computation software package based on the method of moments (FEKO). Three different configurations of the shielding enclosure were considered: a single shell of copper (thickness d=20 µm, radius 0.1 m), a double shell of copper (d=10 µm each, radii 0.1m and 0.115m) and a thin double shell of copper (d=1 µm each, radii 0.1m and 0.115m). The results have been compared to a realistic shielding enclosure of a PET detector module (see figure 1).

Results
The double shell setup is found to improve screening at high frequencies as compared to the single shell setup (see figure 2, black dashed against black solid line): while showing the same response towards low frequency fields, shielding at high frequencies is substantially improved. This also results in a faster decay and lower amplitude of the eddy currents and thus in a reduction of the disturbing influences of the gradient fields while maintaining the required shielding at the unwanted electromagnetic emission frequencies of the PET detector electronics at higher frequencies (compare dashed black line to solid blue line in figure 2).

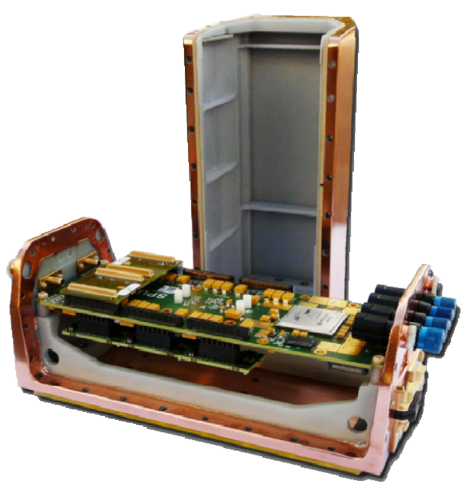

Figure 1: Current shielding setup

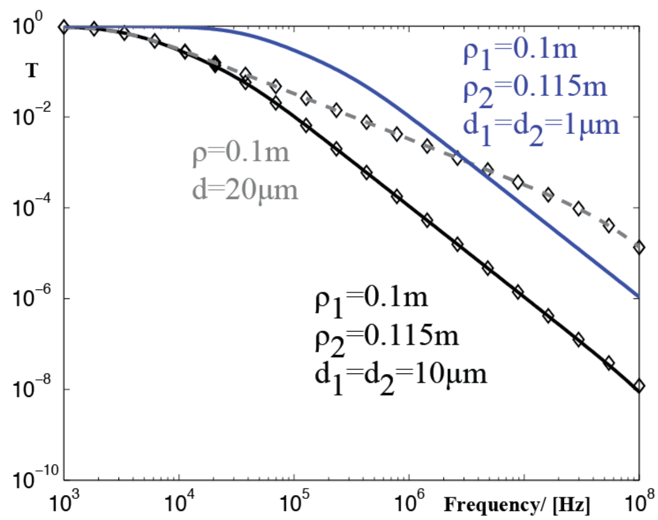

Figure 2: Transmission coefficient T:=B_inside/B_outside against frequency, results of numerical computation are given as square symbols

Conclusions
Shielding enclosures with multiple shells were found to exhibit favorable advantages compared to shielding setups with a single shell of conducting material: while maintaining the response towards low frequency (e.g. MR gradient) fields, splitting a single shell into multiple shells small distances apart allows for much better shielding factors at high frequencies. As desired in a PET/MR device, shielding at high frequencies may be drastically improved while not affecting the low frequency parts of the magnetic fields. This allows for a reduction in total summed shell thickness and therefore a much better transparency to MR gradient fields.