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Towards OPM-MEG in a single MuMetal layer magnetically shielded room

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Background:
Magnetoencephalography (MEG) systems using optically pumped magnetometers (OPMs) require magnetically shielded rooms (MSRs); typically built from 2–5 layers of high-permeability material (e.g., MuMetal) and a conductive layer (e.g., copper) to block external magnetic fields. While effective, current MSRs are heavy (2,500–13,000 kg) and difficult to install (>3 m high), limiting OPM-MEG deployment. OPM-MEG has been demonstrated in MSRs with one MuMetal and one copper layer [1] but removing the copper would further cut costs and simplify installation.

Method:
We built a MSR using a single 1.5 mm-thick MuMetal layer, with an internal/external footprint of 1.3×1.3/1.6×1.6 m², a height of 2/2.5 m, and a weight of 1,100 kg—making it compatible with most rooms and floors.

Results:
Fluxgate measurements show a static field of 223 nT (52 dB shielding relative to the unshielded measurement) and baseline noise of 4.5 pT/√Hz (>24.8 dB). The largest AC spike is the 50Hz powerline of 1063 pT/√Hz (31 dB).

Outlook:
Residual fields in the MSR remain too high for OPM operation. We are developing active shielding and signal processing techniques to reduce the field, including asymmetric electromagnetic coil designs (to account for MuMetal interactions and off-centre patient head position) and FPGA-driven active compensation at DC and AC. We will also present OPM-MEG data acquired with controlled noise generated by coils inside a 5-layer MSR to simulate conditions in a lightly shielded MSR. This data shows that spatiotemporal signal space separation [2] combined with improved calibration [3], [4] can reduce noise levels from c.5 pT/√Hz to c.100fT/√Hz. These results suggest that, with active shielding to address the powerline, OPM-MEG in a single-layer MSR is achievable.

References:
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[4] R. M. Hill et al., "Determining sensor geometry and gain in a wearable MEG system,"Imaging Neuroscience, vol. 3, Apr. 2025, doi: 10.1162/imag_a_00535.

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