

# An active–passive magnetically-shielded test-bed for optically pumped magnetometers

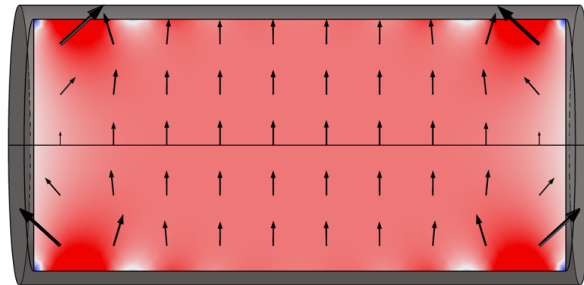
**P.J. Hobson**<sup>1</sup>, M. Packer<sup>1</sup>, N. Holmes<sup>1,2</sup>, A. Davis<sup>1</sup>, P. Patel<sup>3</sup>, D. Holmes<sup>3</sup>, R. Harrison<sup>3</sup>, J. Chalmers<sup>3</sup>, B. Styles<sup>3</sup>, D. Woolger<sup>3</sup>, D. Sims<sup>1</sup>, M.J. Brookes<sup>1,2</sup>, R. Bowtell<sup>1,2</sup>, and T.M. Fromhold<sup>1</sup>

<sup>1</sup>School of Physics and Astronomy, University of Nottingham, Nottingham, NG7 2RD, UK.

<sup>2</sup>Sir Peter Mansfield Imaging Centre, University of Nottingham, Nottingham, NG7 2RD, UK.

<sup>3</sup>Magnetic Shields Ltd, Staplehurst, TN12 0DS, UK.

We design a test-bed for optically pumped magnetometers that combines an optimised multi-layer cylindrical passive shield and active target field coils [1–3]. These coils account for the electromagnetic coupling between shield and coil in their topology, overcoming a longstanding difficulty with shielded coil design. We use a combination of analytical methods and numerical simulations to design optimal passive shielding, including entry holes, that integrates with three uniform and six gradient field coils housed near the inner shield’s interior surface. The uniform and gradient field coils deviate by less than 0.4% and 2%, respectively, inside the volume within half the inner shield diameter and length. The shield has a large internal volume with maximised shielding efficiency, minimised shield-induced Johnson noise, flexible cancellation of background field deviations, and adaptive generation of various complex magnetic field landscapes.



**Figure 1.** Magnitude (red high) and orientation (black arrows) of the magnetic field generated by an active-passive system simulated using COMSOL Multiphysics.

[1] M. Packer, P.J. Hobson, N. Holmes, J. Leggett, P. Glover, M.J. Brookes, R. Bowtell, and T.M. Fromhold, Optimal Inverse Design of Magnetic Field Profiles in a Magnetically Shielded Cylinder, *Phys. Rev. Applied* **14**, 054004 (2020).

[2] M. Packer, P.J. Hobson, N. Holmes, J. Leggett, P. Glover, M.J. Brookes, R. Bowtell, and T.M. Fromhold, Planar Coil Optimization in a Magnetically Shielded Cylinder, *Phys. Rev. Applied* **15**, 064006 (2021).

[3] M. Packer, P.J. Hobson, A. Davis, N. Holmes, J. Leggett, P. Glover, M.J. Brookes, R. Bowtell, and T.M. Fromhold, Magnetic Field Design in a Cylindrical High Permeability Shield: The Combination of Simple Building Blocks and a Genetic Algorithm, Preprint (2021).