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Postdoctoral fellowship: Gradient optimization and safety modeling (peripheral nerve stimulation, cardiac stimulation)

I am looking for highly accomplished and motivated candidates to work in my laboratory located in the Athinoula A. Martinos Center for Biomedical Imaging in Charlestown, Massachusetts, on gradient coil design, optimization and safety evaluation (modeling and measurements). The laboratory is part of the Massachusetts General Hospital. The ideal candidate will have a PhD in physics, engineering or similar. Excellent coding skills are crucial for this position. Experience with MRI gradient coils and/or MRI safety is preferred. A proven track record of publications is essential.

My group has developed computational methods for modeling and measurement of peripheral nerve stimulation (PNS) as well as cardiac stimulation (CS) by induced MRI gradients. The rapidly switched gradients using in MRI induce electric fields in the body via Faraday induction that can stimulate peripheral nerves and lead to concerns about stimulation of the Purkinje fibers located in the heart. Our modeling work has led to new insights into PNS and CS. For example, we proposed a modified boundary element modeling method that incorporates explicit PNS constraints, thus leading to gradient coil designs with intrinsically low PNS propensity **[1-3]**. We have also simulated CS in realistic body and porcine models and shown that our predictions match cardiac stimulation measurements in pigs **[4]**. A central result is that the current CS safety limit used in IEC 60601-2-33 can be raised by ~50% without fundamentally affecting the cardiac safety profile of MRI gradient systems (we are working with the IEC to incorporate those results in the next update of the 60601-2-33 standard) **[5]**. We are exploring a number of projects building on this success, including creation of realistic anatomical/nerve body models, fast PNS monitoring via deep learning and linear models, gradient design and optimization, and magneto-stimulation of peripheral nerves for therapeutic purposes.

My laboratory is part of the Magnetic Resonance Physics and Instrumentation Group (MRPIG) at the A. A. Martinos Center for Biomedical Imaging. The MRPIG houses 12 Principal Investigators and dozens of postdocs and graduate students who develop instrumentation and computational methods to bring new levels of understanding of disease and biology using non-invasive imaging. Our goal is to bridge experimental and computational areas by developing new hardware methodology and expanding image acquisition and reconstruction methods to exploit newly generated capabilities. Some of the projects by the group include: Ultra-high field neuro-MRI (UHF), methods for functional brain imaging and connectomics, RF coil detector and transmit arrays, parallel imaging acquisition and reconstruction methods for speeding up MRI and motion mitigation, parallel transmit pulse design, RF safety for patients with deep brain stimulators, portable MR technology, developing Magnetic Particle Imaging (MPI) for studying brain function.

The A. A. Martinos Center for Biomedical Imaging is a large research institute home to more than 350 investigators, postdocs and graduate students with deep ties to the Massachusetts General Hospital, the Massachusetts Institute of Technology and Harvard Medical School. It is an internationally renowned center with unique scanning capabilities including three 3T MRI scanners, two PET-MRI scanners, two 7T MRI scanners, one ‘Connectome’ high-gradient strength 3T system as well as machine shops, an RF laboratory, a maker space and extensive computational capabilities. Members of the center animate regular science and social events including the weekly ‘Brainmap’ science seminars, ‘Science on Tap’ and ‘Why & How’ events, Martinnovate (entrepreneurship talks and events) and the Molecular Imaging speaker series, which makes it an ideal environment to learn and grow scientifically as well as personally.

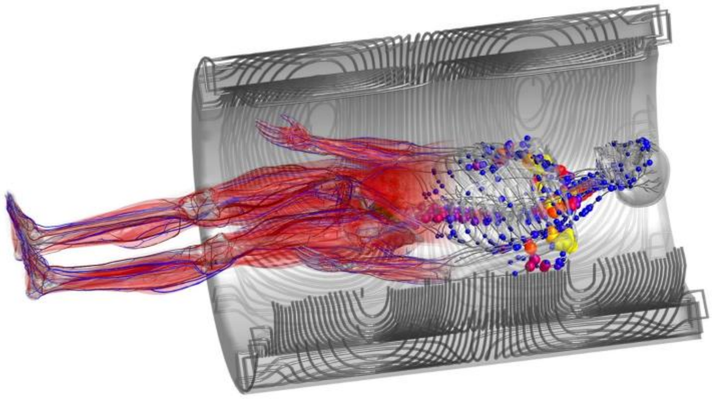
[1] Davids M, Guérin B, Klein V, Wald LL. Optimization of MRI gradient coils with explicit peripheral nerve stimulation constraints. IEEE transactions on medical imaging. 2020 Sep 11;40(1):129-42.

[2] Davids M, Vendramini L, Klein V, Ferris N, Guerin B, Wald LL. Experimental validation of a PNS-optimized whole-body gradient coil. Magnetic resonance in medicine. 2024 Oct;92(4):1788-803.

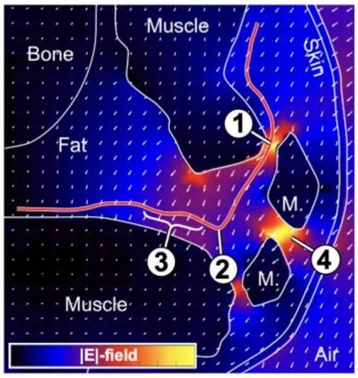
[3] Davids M, Dietz P, Ruyters G, Roesler M, Klein V, Beckett AJ, Vu AT, Guérin B, Feinberg DA, Wald LL. Peripheral nerve stimulation informed design of a high-performance asymmetric head gradient coil. Magnetic Resonance in Medicine. 2023 Aug;90(2):784-801.

[4] Klein V, Coll-Font J, Vendramini L, Straney D, Davids M, Ferris NG, Schad LR, Sosnovik DE, Nguyen CT, Wald LL, Guérin B. Measurement of magnetostimulation thresholds in the porcine heart. Magnetic resonance in medicine. 2022 Nov;88(5):2242-58.

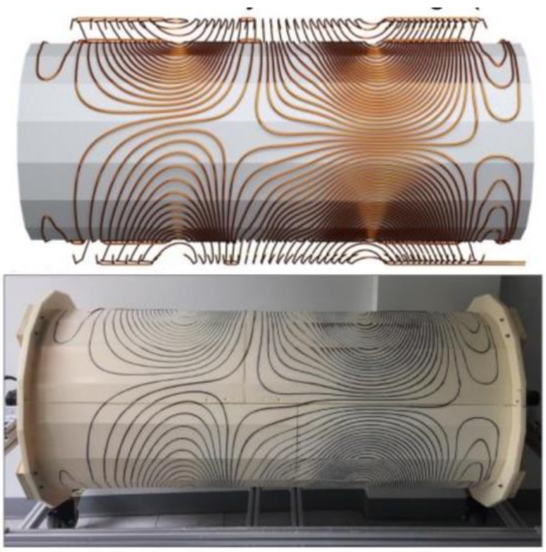
[5] Klein V, Davids M, Ferris NG, Edmonson J, Gebhardt M, Rattenbacher D, van den Brink JS, Steckner M, Wald LL, Guérin B. Electromagnetic and Electrophysiological Modeling of Cardiac Stimulation Thresholds in 13 MRI Gradient Systems and 56 Body Models. Magnetic Resonance in Medicine. 2026 Apr 12.



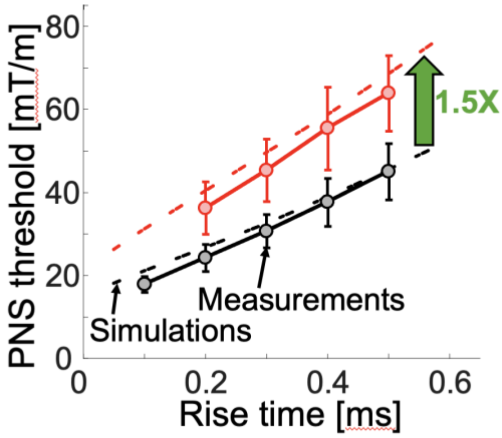
View of one of our detailed anatomical/nerve model inside an MRI gradient coil. The color 'blobs' on the right show activation areas indicating strong probabilities of PNS.



Four typical scenarios: 1) The nerve passes through a E-field hotspot. 2) High curvature in uniform E-field. 3) Low curvature in uniform E-field. 1) and 2) typically lead to activation.



Designed and constructed prototype of a PNS-optimized Y-axis body gradient coil.



Comparison between measured (solid) and simulated PNS thresholds (dash). ***Black****: Conventional design.* ***Red****: PNS-optimized design. Our optimization yields a 50% increase of thresholds compared to the conventional design.*

Please contact me directly for more information if interested in this position.