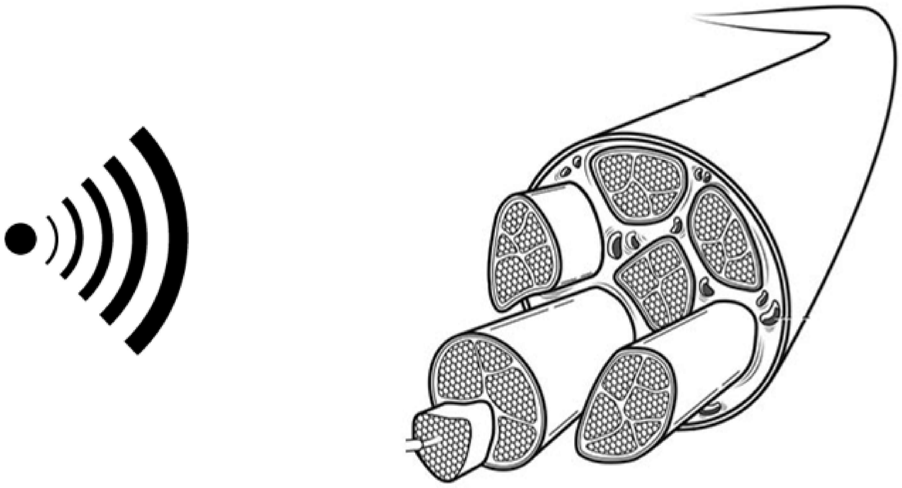
Ultrasound Neuromodulation

Focused Ultrasound Stimulation (FUS) is a non-invasive therapeutic tool with great potential, widely used on humans for ablation therapies and diagnostic imaging. It has recently emerged as a promising technology to achieve reliable, selective and noninvasive neuromodulation of various targets of the central nervous system of rodents, non-human primates and humans (King et al., 2013; Legon et al., 2014). A myriad of applications can therefore be envisaged in which US would replace the standard and invasive electrical stimulation. However, in order for FUS to become a reliable neuromodulation technology, we need a deeper understanding of the fundamental mechanism(s) by which ultrasonic waves can modulate neural activity.



We wish to assess if/how FUS can be applied for neuromodulation of the peripheral nervous system (and especially in autonomic pathways) where it could find a number of useful applications. To do so, we are currently developing a modeling framework to predict how low-intensity ultrasonic waves can modulate the activity of different types of peripheral fibers. This framework is based on the *neuronal intramembrane cavitation excitation* (NICE) theory recently proposed by Plaksin et al., that provides accurate predictions of central nervous system (CNS) neurons excitation for a wide range of sonication conditions.

We have recently developed a multiScale Optimized Neuronal Intramembrane Cavitation (SONIC) model (Lemaire et al., 2019), a novel version of the NICE model that is computationally efficient and more interpretable. We have integrated this model with different point-neuron models to predict their electrical responses to low-intensity ultrasound stimulation, and designed an interactive web explorer to visualize those responses across the multi-dimensional stimulation parameter space.

We now seek to extend this biophysical model to realistic morphological representations of peripheral axons and to couple it with computational acoustic models, in order to obtain a multiscale framework providing reliable, accurate predictions of fiber activation/inhibition upon FUS exposure. Several experimental investigations are performed in parallel, from simple isolated neural structures to autonomic nerves in their anatomical environment, in order to validate and/or refine the different scales of the model and ultimately provide a relevant predictive framework.

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Contact

If you are interested in this research topic and wish to learn more, don't hesitate to contact us:

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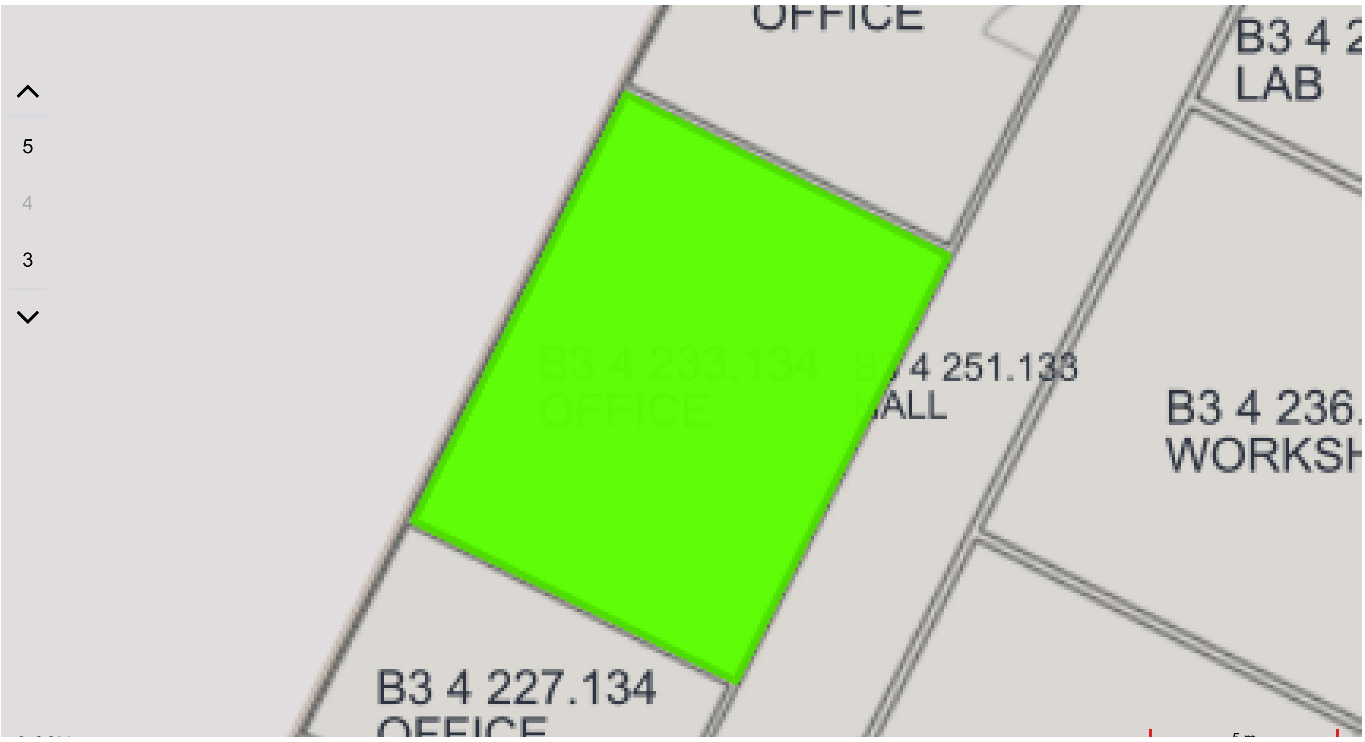

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