The ideal form of a neural-interfacing device is highly dependent upon the anatomy of the region with which it is meant to interface. Multiple-electrode arrays provide a system which can be adapted to various neural geometries. Computational models of stimulating systems have proven useful for evaluating electrode placement and stimulation protocols, but have yet to be adequately adapted to the unique features of the hippocampus.

As an approach to understanding potential memory restorative devices, an Admittance Method-NEURON model was constructed to predict the direct and synaptic response of a 400 micron-thick region of the rat dentate gyrus to electrical stimulation of the perforant path. The volume contained 50,000 unique granule cells and 10,000 explicitly modeled entorhinal cortical axons, making up over 11 million simultaneously solved compartments. These two layers were connected by 11.625 million synapses.

Predicted LFPs (red signal) exhibit a characteristic population spike (PS) as observed in experimental evoked potentials (black signals) elicited by a 200 μA biphasic, square-wave pulse [3].

Spiking activity at most locations saturates above stimulus amplitudes of ~500 μA (shown at right). (A) When stimulating at cell body locations, granule cell activity versus stimulus amplitude follows a sigmoidal trend. (B) When stimulating at PP locations, the trend is more logarithmic. (C) The differences between (A) and (B) gives rise to greater efficiency at low amplitude when stimulating in the PP.

For nearly all stimulating conditions the half-height width (HHW) of PS was shorter (ms) when stimulating at the cell body layer and PP at the crest relative to supra/infra locations.

$$U = \frac{W_1 PS_{max} + W_2 PS_{efficiency} + W_3 [max(HHW) - HHW]}{W_4 + W_5 + W_6}$$

Output of the multi-objective optimization function (U, above) for MPP/LPP (E, left) and CBL (E, right) stimulation cases is presented in the panel to the right. High values of U indicate strong PS. The PS amplitude and power efficiency were maximized and the half-height width was minimized with equal weighting in this optimization. (CBL-cell body layer, MPP/LPP-medial/lateral perforant path).

### References