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A NEUROSCIENCE PERSPECTIVE ON DENDRITES FOR NEUROMORPHIC COMPUTING

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Sandia National Laboratories

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U.S. DEPARTMENT of ENERGY NNSA

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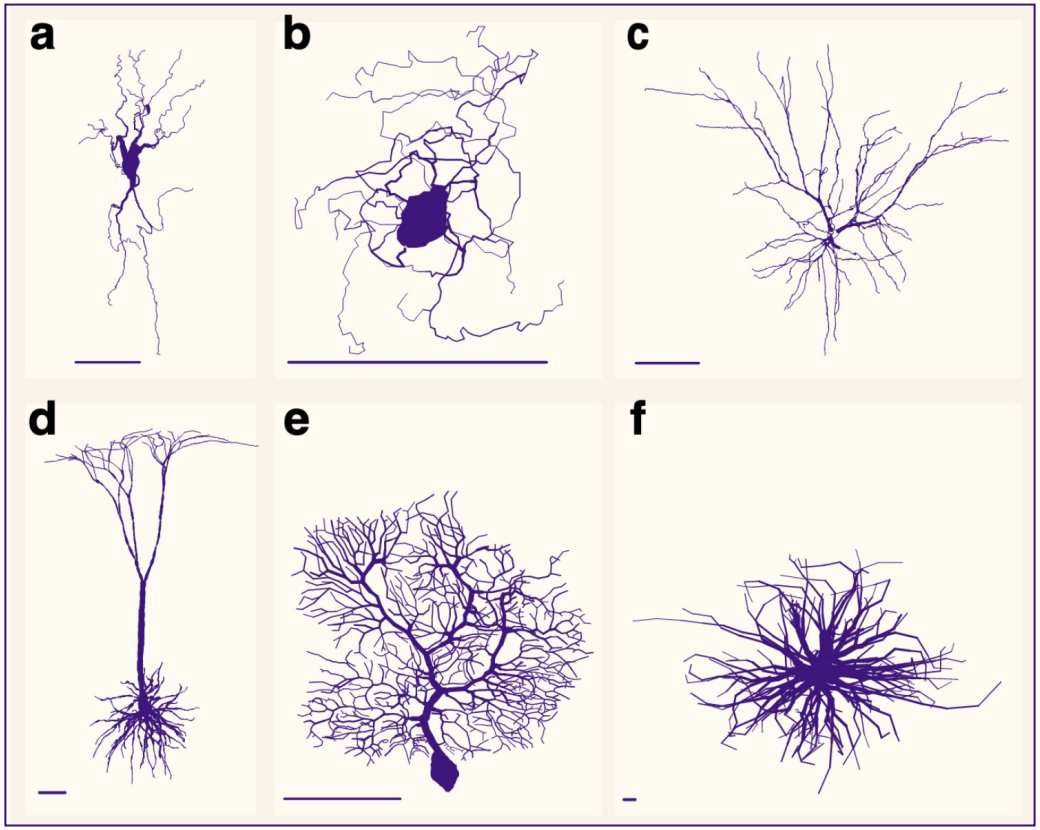
BIOLOGICAL NEURONS (AND THEIR DENDRITES) ARE COMPLEX



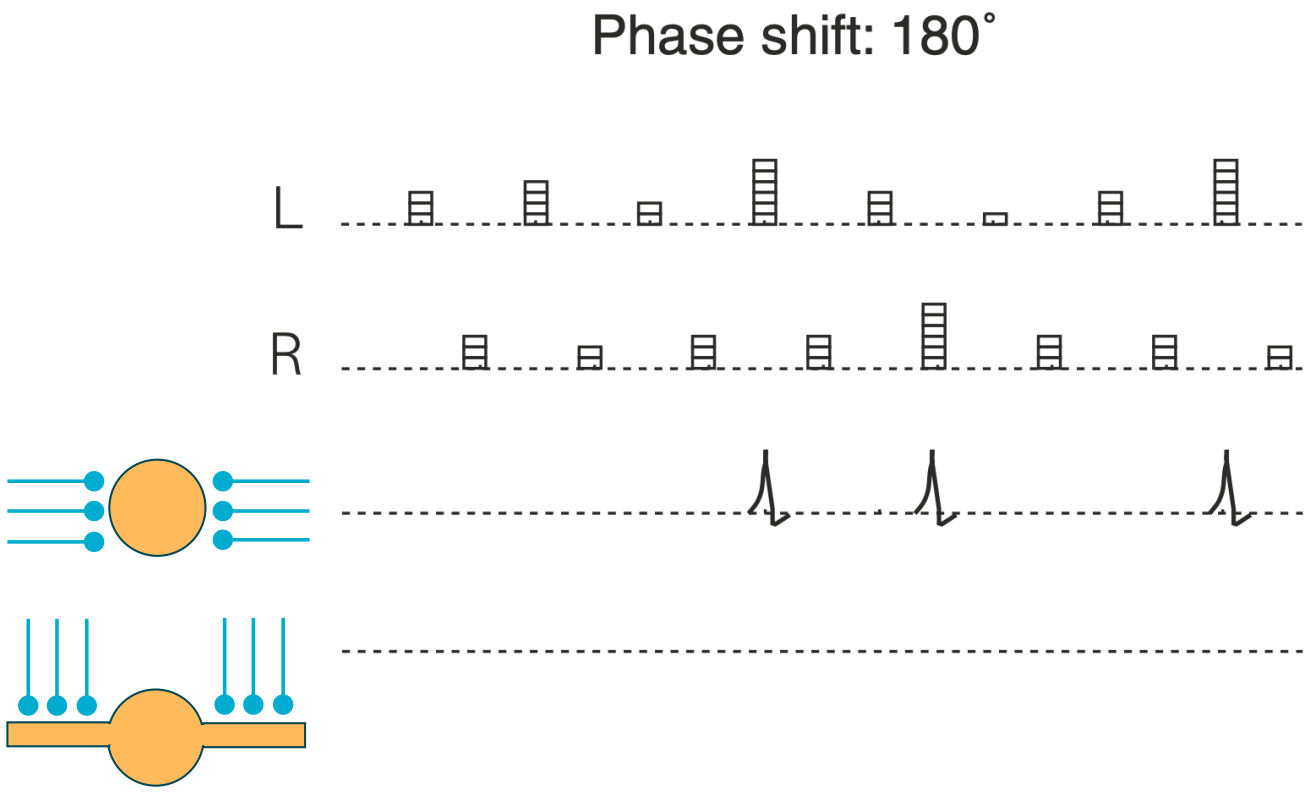
from Koch & Segev (2000) Nature 3: 1171

Conventional view: dendrites receive and route synaptic inputs

Biological view: dendrites offer a “computational toolkit”. [London et al 2005]

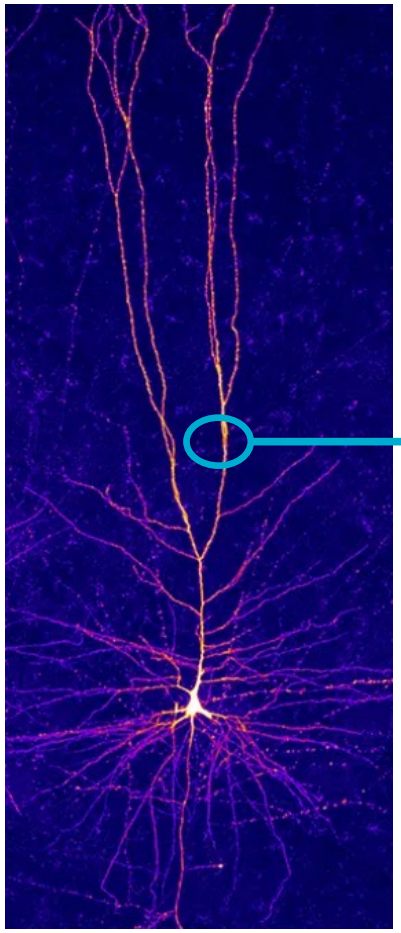
What inspiration should we draw from biology for neuromorphic/ artificial systems?

CONDUCTANCE CHANGE AS A GATE: COINCIDENCE DETECTION IN NUCLEUS LAMINARIS

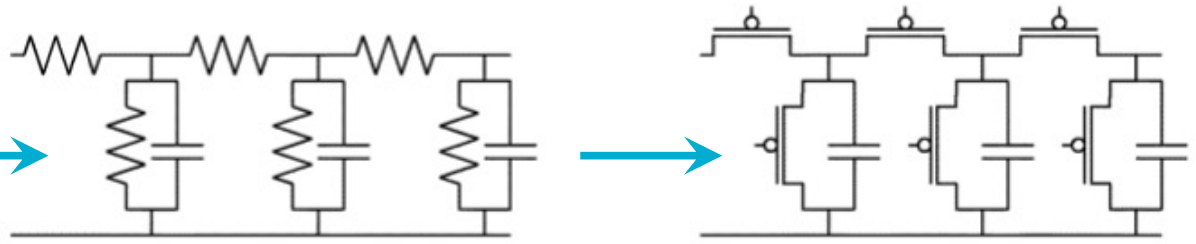


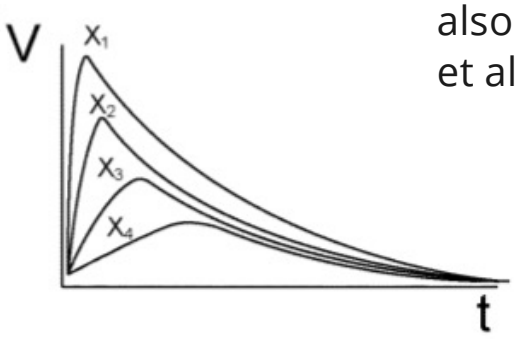
from Agmon-Snir et al 1998, Nature 393: 270

MEMBRANE CONDUCTANCE IN A NEUROMORPHIC DENDRITE



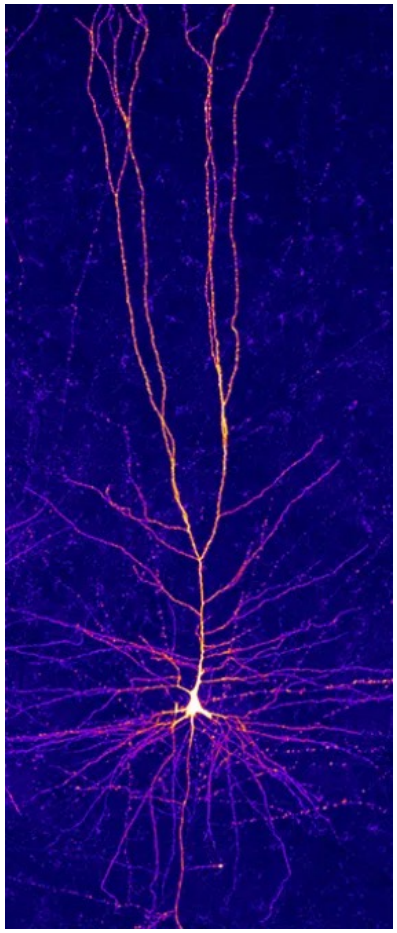
Passive membrane properties were demonstrated by Nease et al in an analog neuromorphic dendrite
[IEEE TBioCAS 6: 76, 2012]

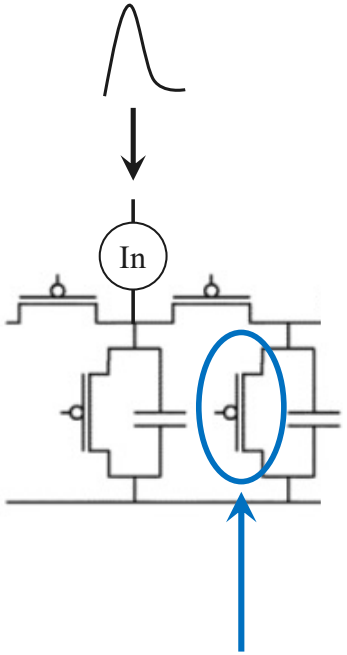




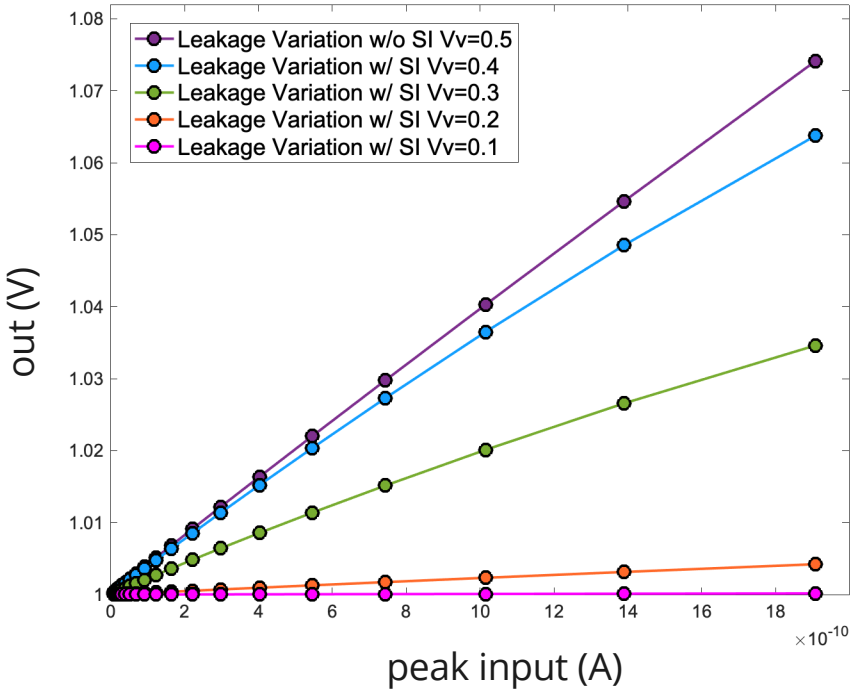
also see George-Cardwell et al 2013

SHUNTING IN A NEUROMORPHIC DENDRITE



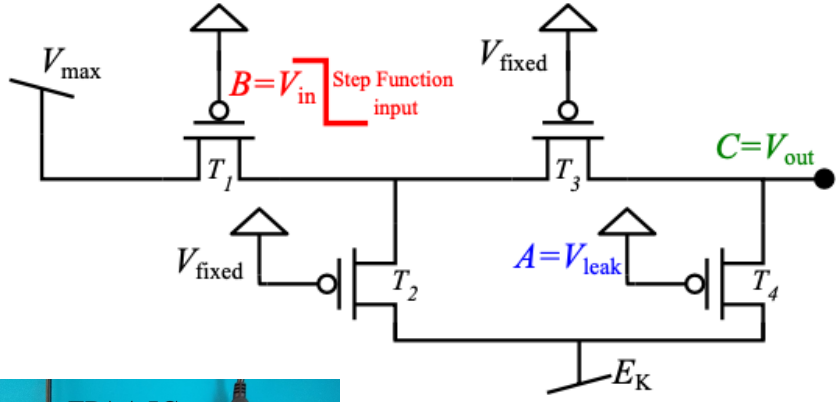


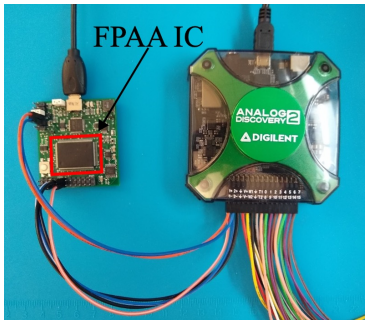
shunting inhibition

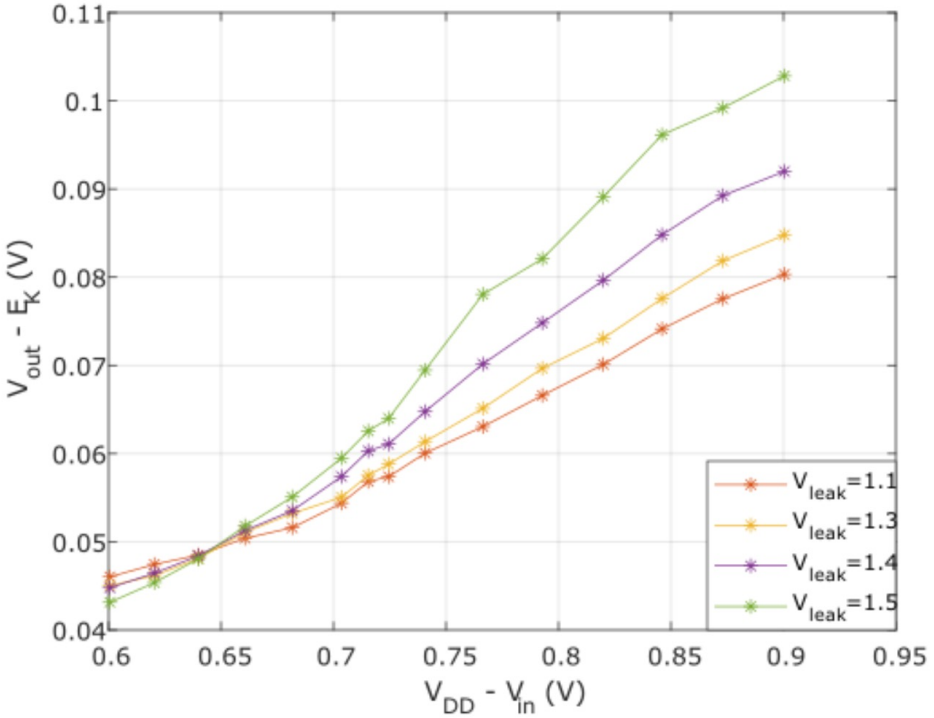


Chance & Cardwell, NICE 2023

SHUNTING IN A NEUROMORPHIC DENDRITE

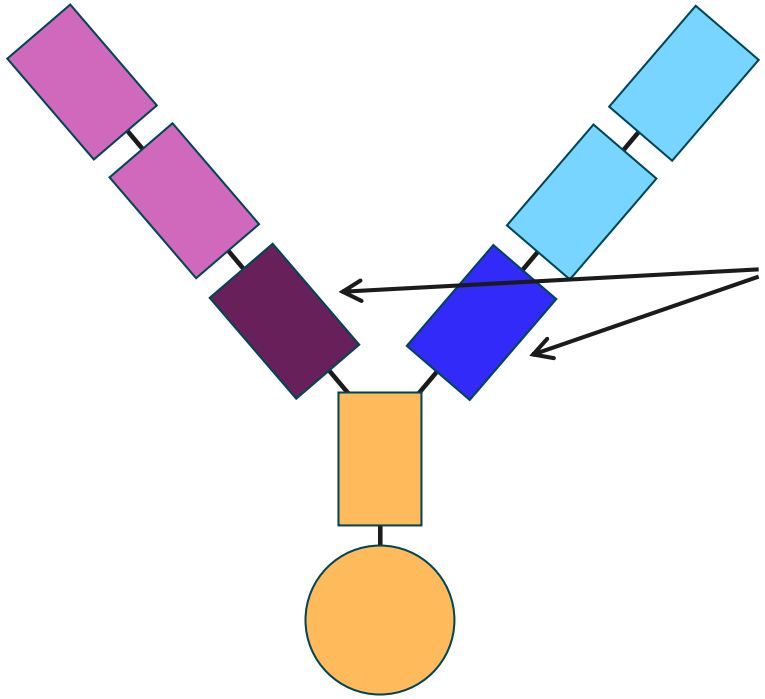






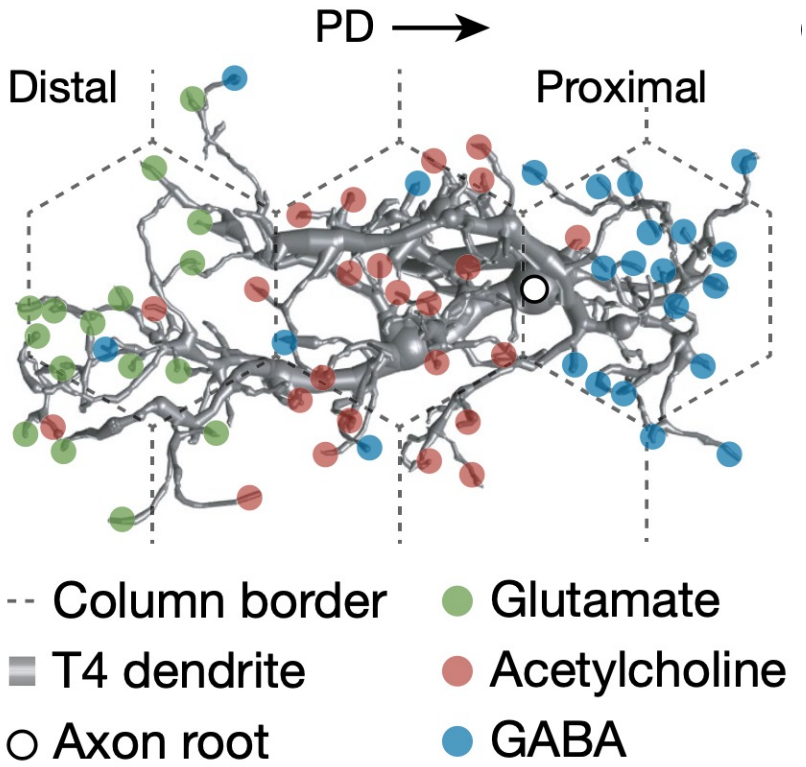
Edwards, Parker, George-Cardwell, Chance & Koziol, IEEE ISCAS2024

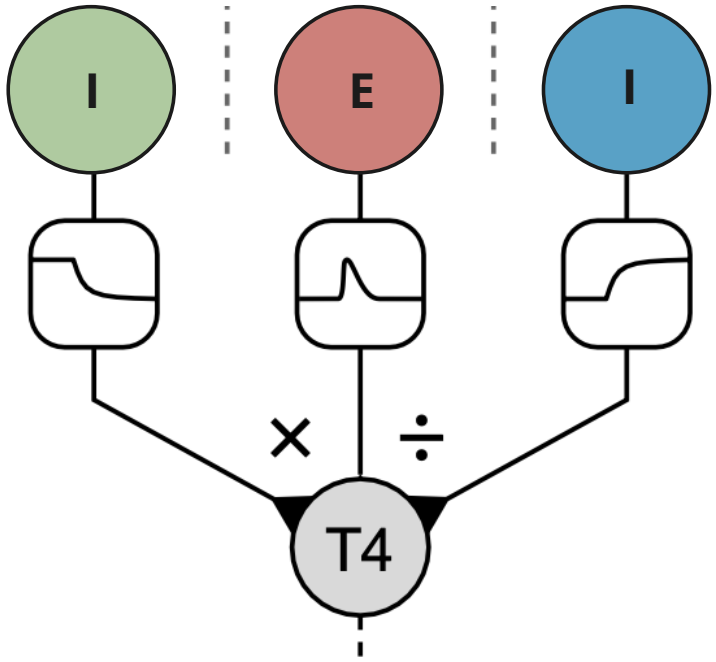
SHUNTING ON THE PROXIMAL DENDRITE AS A GATE



Shunting as “attention-like” mechanism

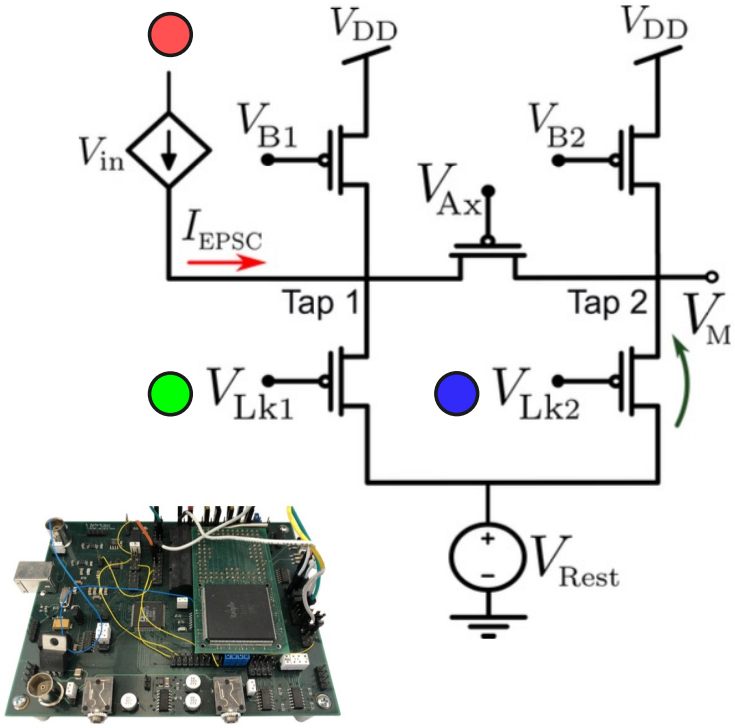
DIRECTION SELECTIVITY FROM SHUNTING IN A BIOLOGICAL DENDRITE





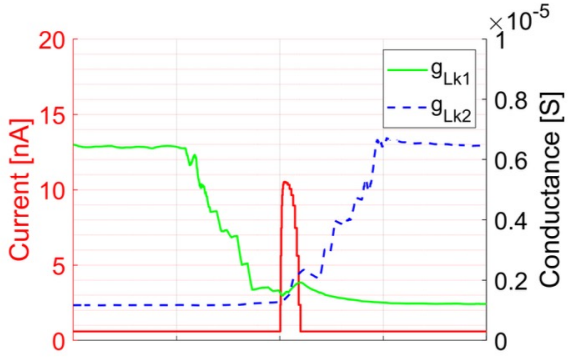
adapted from Groschner et al, 2022 Nature 603: 119

DIRECTION SELECTIVITY FROM SHUNTING IN A NEUROMORPHIC DENDRITE

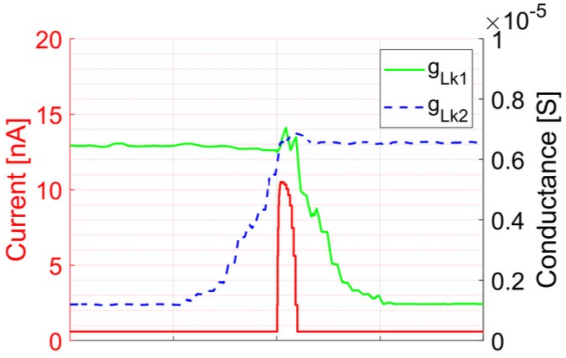


from Parker et al ICONS 2024

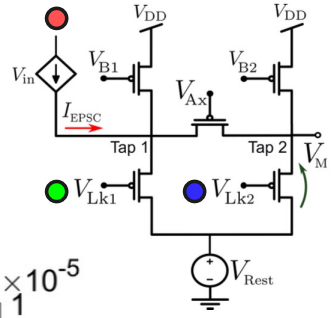
Stimulus Moves in Preferred Direction



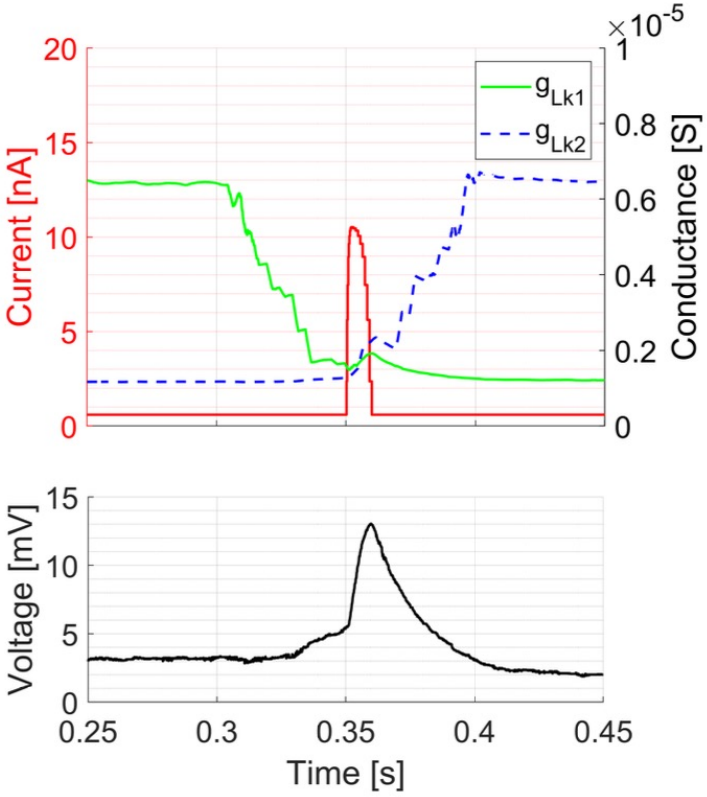
Stimulus Moves in Non-Preferred Direction



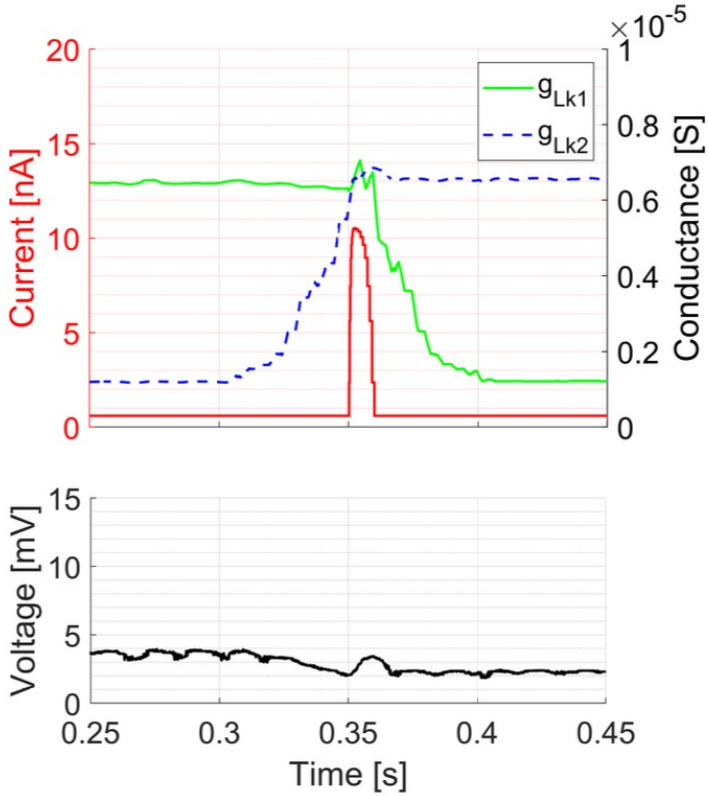
DIRECTION SELECTIVITY FROM SHUNTING IN A NEUROMORPHIC DENDRITE



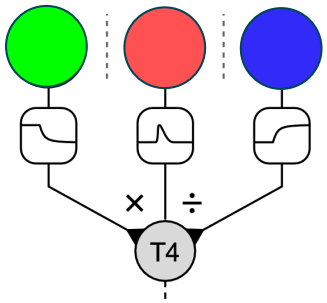
Preferred Direction

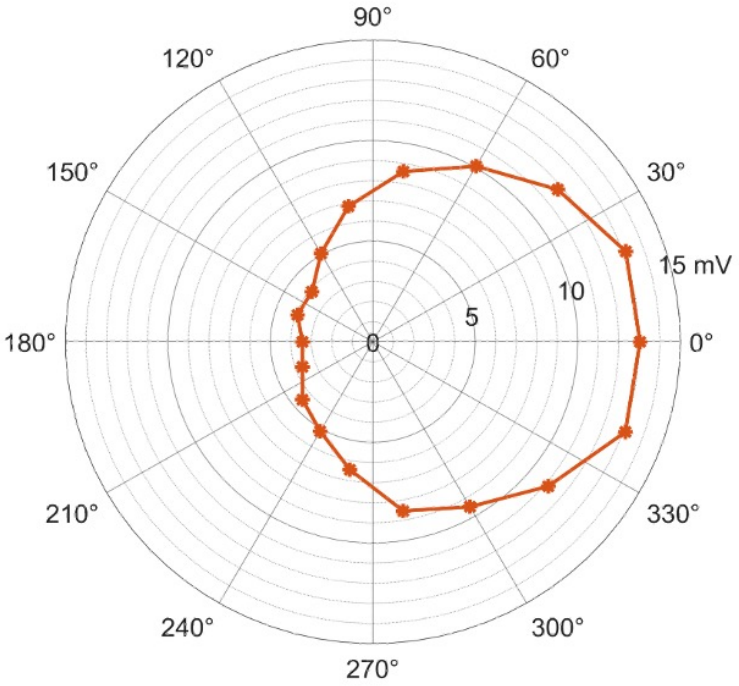


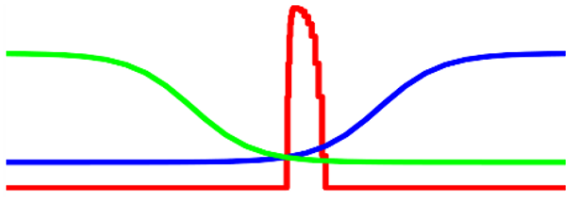
Non-Preferred Direction



DIRECTION SELECTIVITY FROM SHUNTING IN A NEUROMORPHIC DENDRITE







from Parker et al ICONS 2024

DIRECTION SELECTIVITY FROM SHUNTING IN A NEUROMORPHIC DENDRITE

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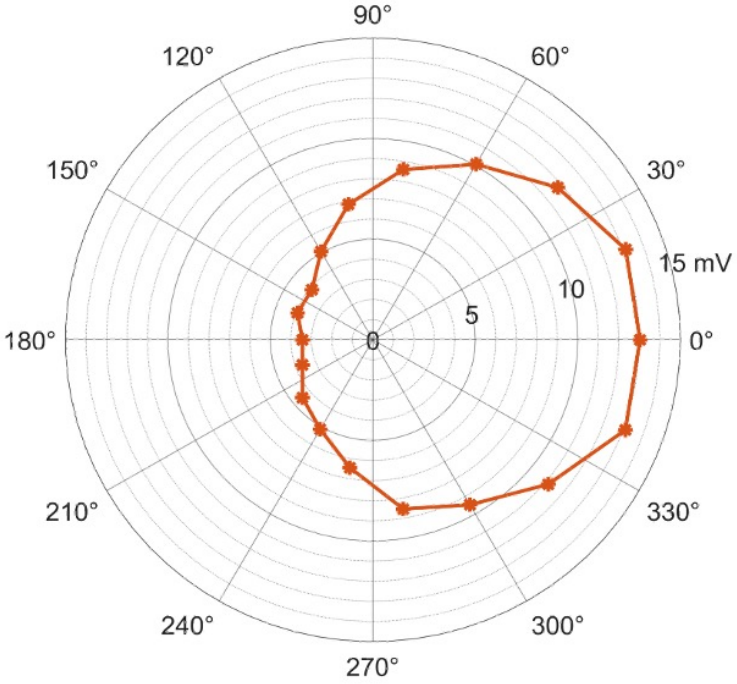
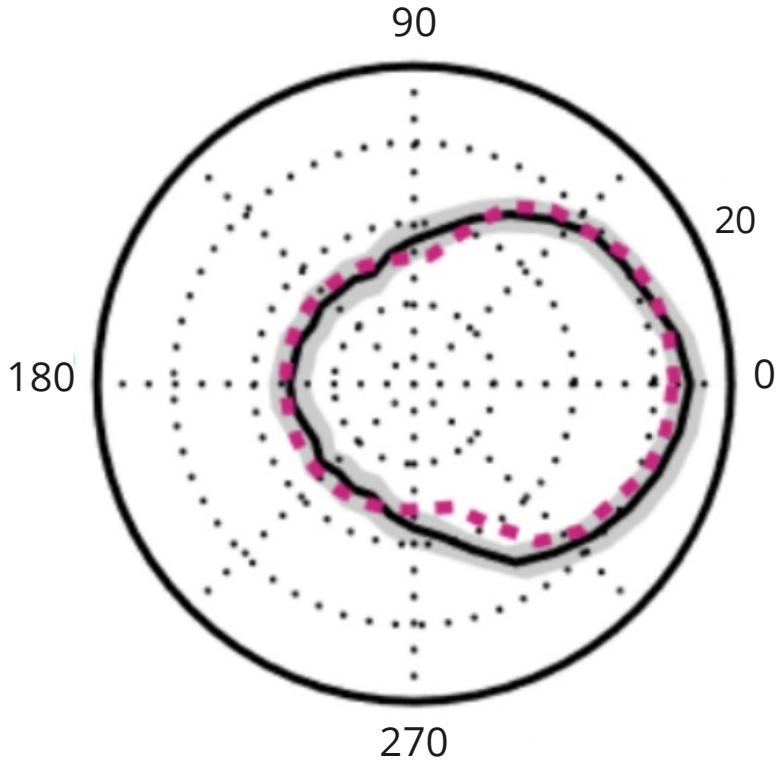
Neuromorphic



Biological Data



from Parker et al ICONS 2024

THE END

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