Comparison of Simulated Extracellular Spikes from Pyramidal Neurons and Interneurons

Daniel M. Bjørnstad

Master Thesis Presentation

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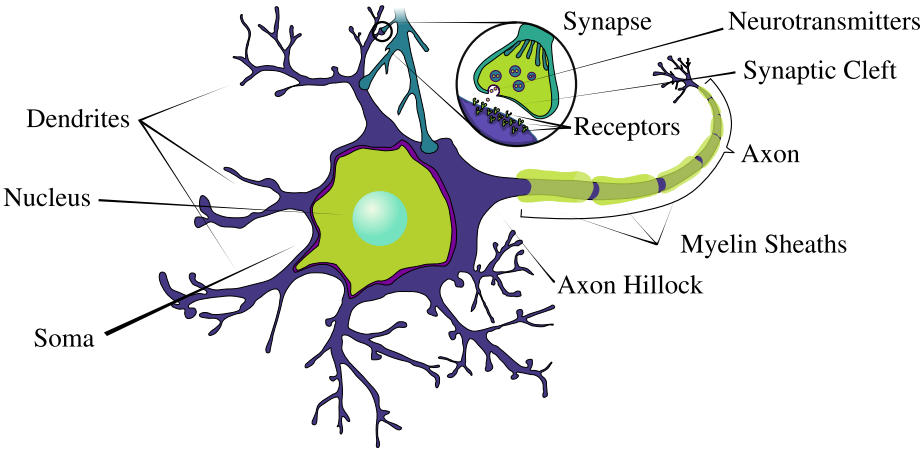
Topic and Motivation

Topic: Differentiate the shape of neurons based on extracellular spike shape using modelling.

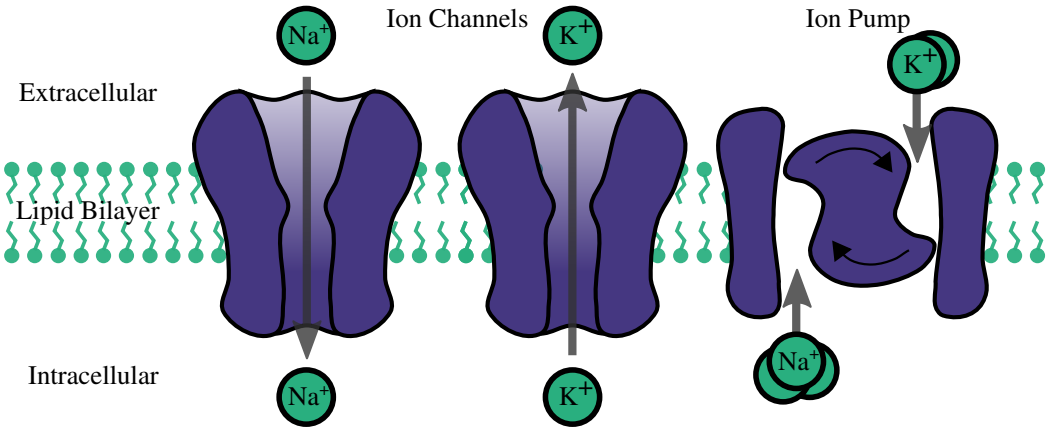
Motivation:

- Neurons of different types have different functions. Classifying them is important.
- Some neurons have shorter spikes than others.
- There has been debate wether using spike width can reliably classify neurons.

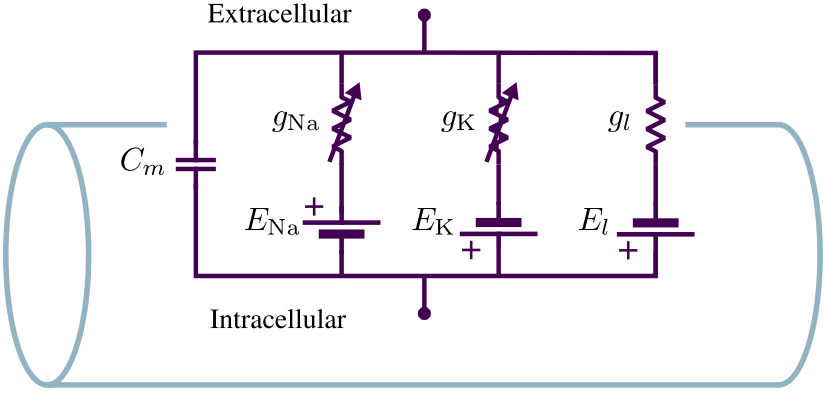
Theory: What are Neurons



The Neuron Membrane



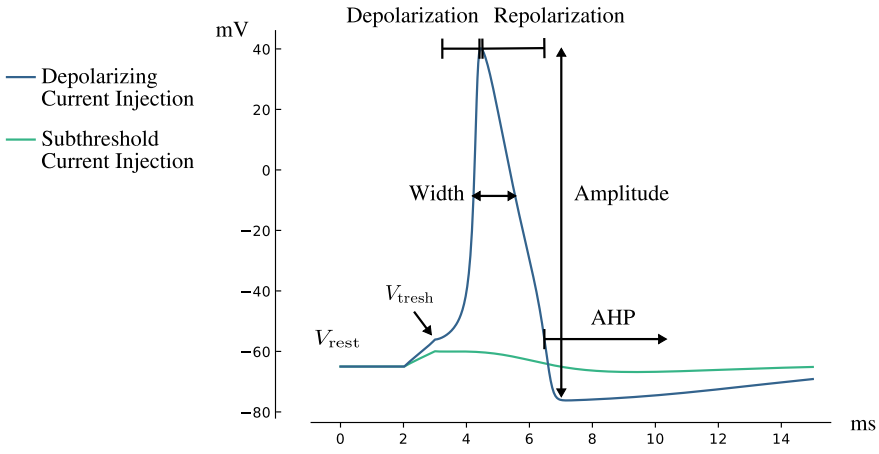
The Membrane Equivalent Circuit: Hudgking and Huxley



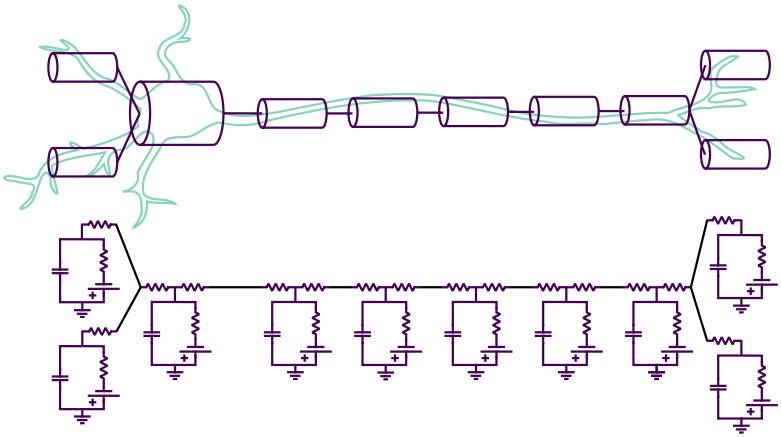
Action Poential: Toilet Model

- Toilet

Action Poential: Anatomy

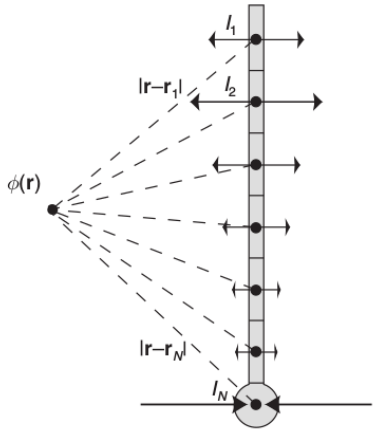


Multicompartmental Models

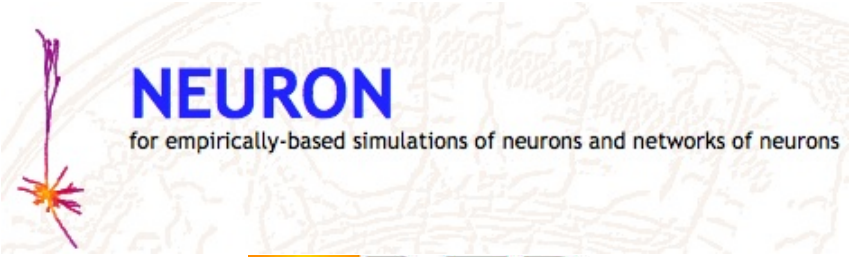


Extracellular Action Potentials (EAPs)

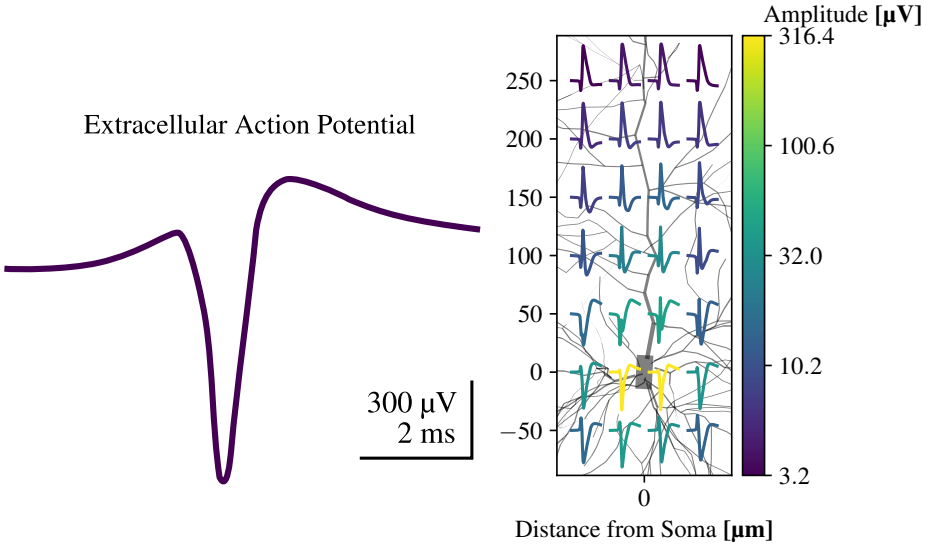
$$\phi(r,t) = \sum_{n=1}^{N} \frac{1}{4\pi\sigma} \frac{I_n(t)}{r_n}$$



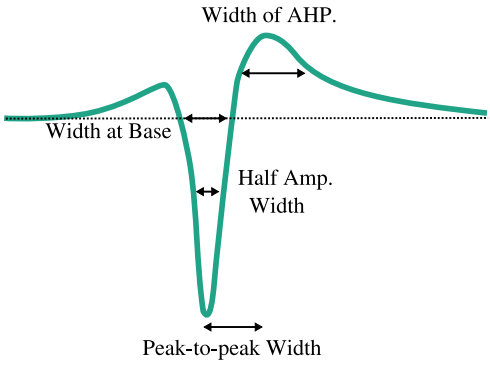
Computer Simulation

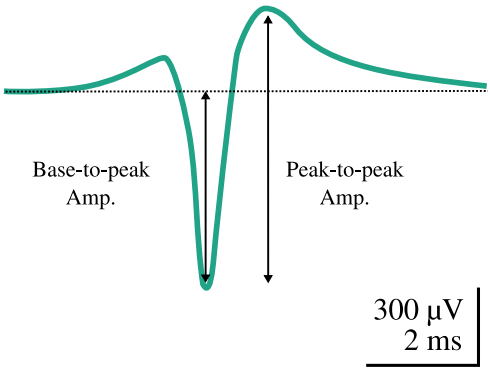


EAPs Vary in Shape and Amplitude



Spike Width Definition



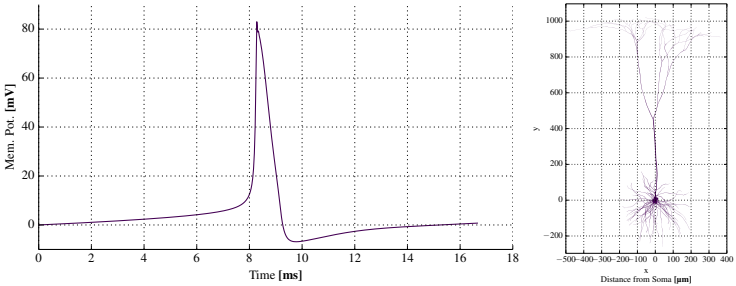


Results Part I: Model Validation

- Verify the simulation environment.

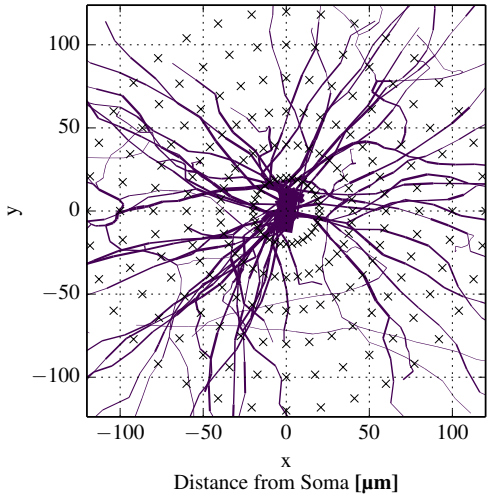
Pettersen and Einevoll 2008

- Play back



Pettersen and Einevoll 2008

- Electrodes placed in the same way as the article.
- Spike width and amplitude measred at every position.

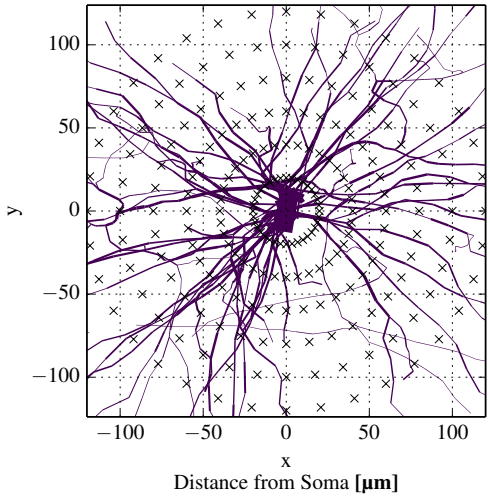


Pettersen and Einevoll 2008

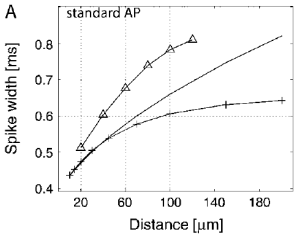
- Electrodes placed in the same way as the article.
- Spike width and amplitude measred at every position.

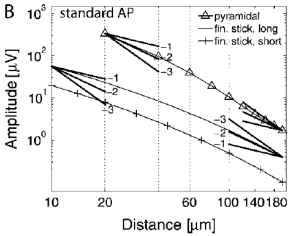
Conlusion:

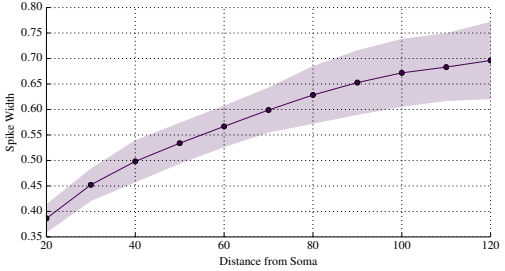
- Results are kvantativly similar.

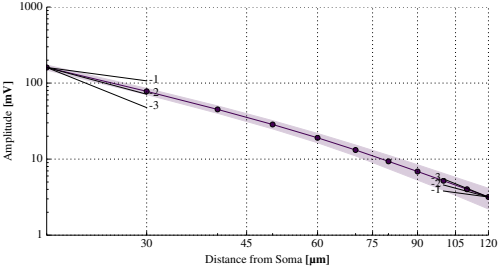


Pettersen and Einevoll 2008



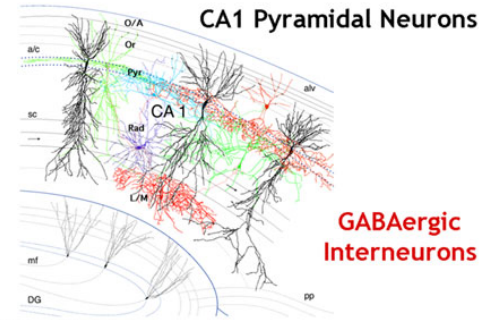






Results Part II: Comparing Pyramidal Neurons and Interneurons

- Neurons have commonly been classified by shape (morphology) and electrical activity.
- Pyramidal neuron and interneurons are 2 types based on shape and location.
- Though the types have also been associated with other properties such as the spike duration and if they excite other neurons or not.

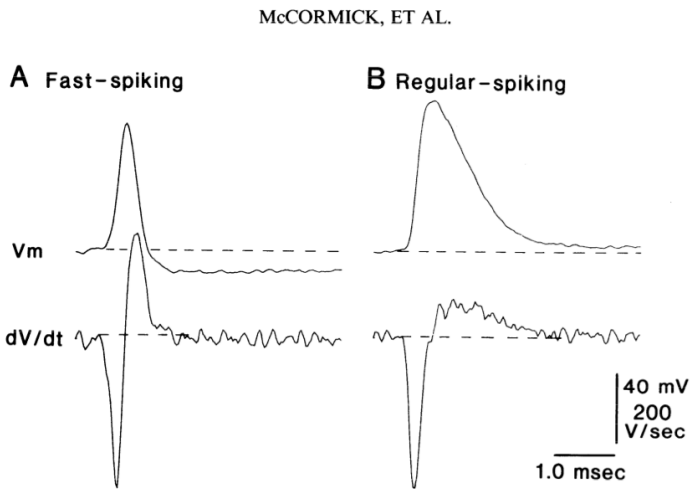


Courtesy of MacIver MB.

Goal

- Does computer models show a difference between interneuron and pyramidal neurons.
- Are certain width and a amplitude definitions better suited for differention.

Prior Research



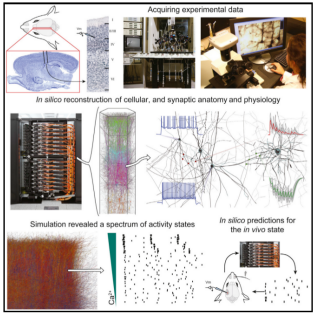
Blue Brain Models

Resource

Cell

Reconstruction and Simulation of Neocortical Microcircuitry

Graphical Abstract



Authors

Henry Markram, Eilif Muller, Srikanth Ramaswamy, Michael W. Reimann, ..., Javier DeFelipe, Sean L. Hill, Idan Segev, Felix Schürmann

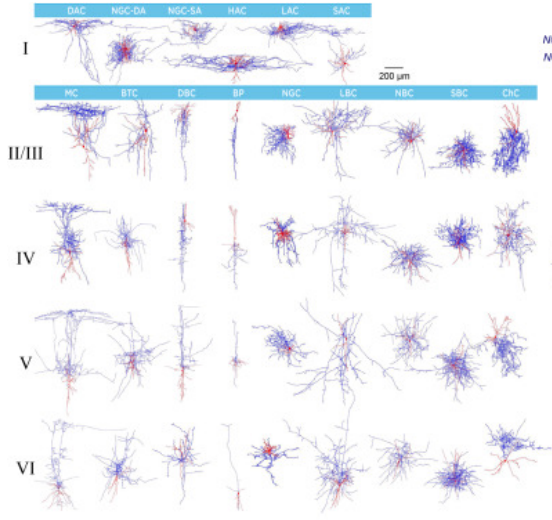
Correspondence

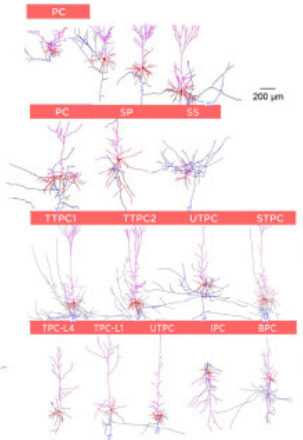
henry.markram@epfl.ch

In Brief

A digital reconstruction and simulation of the anatomy and physiology of neocortical microcircuitry reproduces an array of in vitro and in vivo experiments without parameter tuning and suggests that cellular and synaptic mechanisms can dynamically reconfigure the state of the network to support diverse information processing strategies.

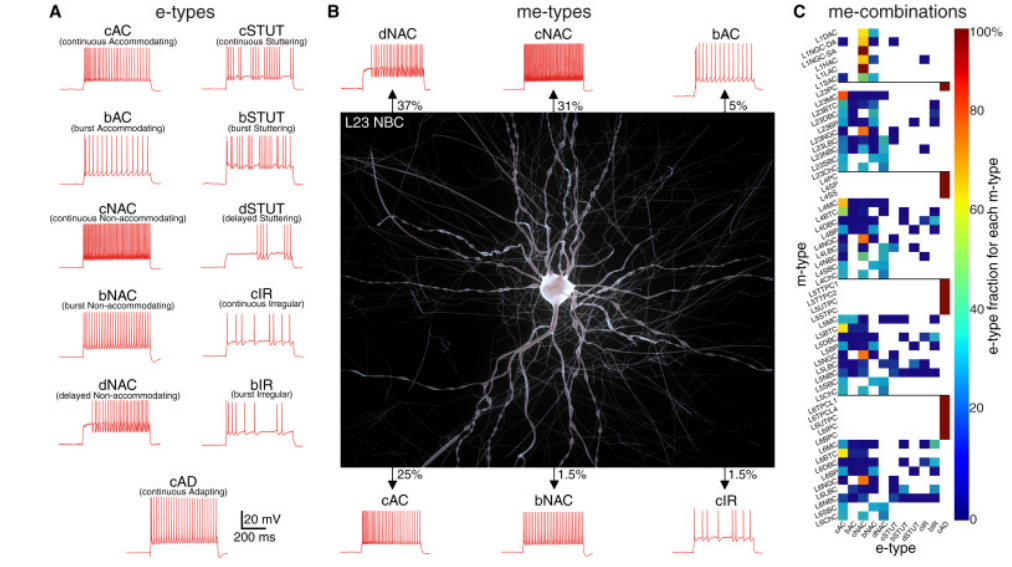
Blue Brain M-types



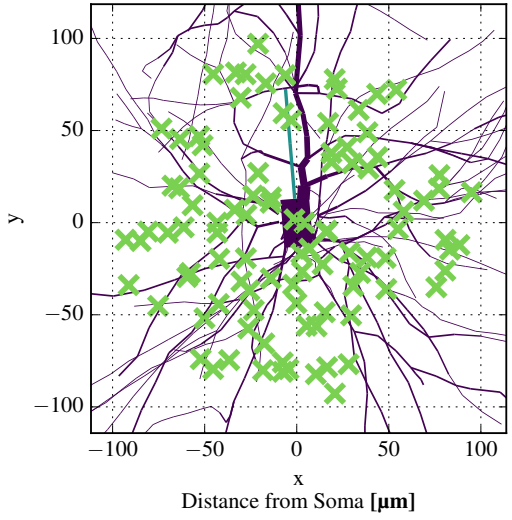


DAC	Descending Axon Cell
NGC-DA	Neurogliaform Cell with dense axonal arborization
NGC-SA	Neurogliaform Cell with slender axonal arborization
HAC	Horizontal Axon Cell
LAC	Large Axon Cell
SAC	Small Axon Cell
MC	Martinotti Cell
BTC	Bitufted Cell
DBC	Double Bouquet Cell
BP	Bipolar Cell
NGC	Neurogliaform Cell
LBC	Large Basket Cell
NBC	Nest Basket Cell
SBC	Small Basket Cell
ChC	Chandelier Cell
PC	Pyramidal Cell
SP	Star Pyramidal Cell
SS	Spiny Stellate Cell
TTPC1	Thick-tufted Pyramidal Cell with a late bifurcating apical tuft
TTPC2	Thick-tufted Pyramidal Cell with an early bifurcating apical tuft
UTPC	Untufted Pyramidal Cell
STPC	Slender-tufted Pyramidal Cell
TPC_L4	Tufted Pyramidal Cell with dendritic tuft terminating in layer 4
TPC_L1	Tufted Pyramidal Cell with dendritic tuft terminating in layer 1
IPC	Pyramidal Cell with inverted apical-like dendrites
BPC	Pyramidal Cell with bipolar apical-like dendrites

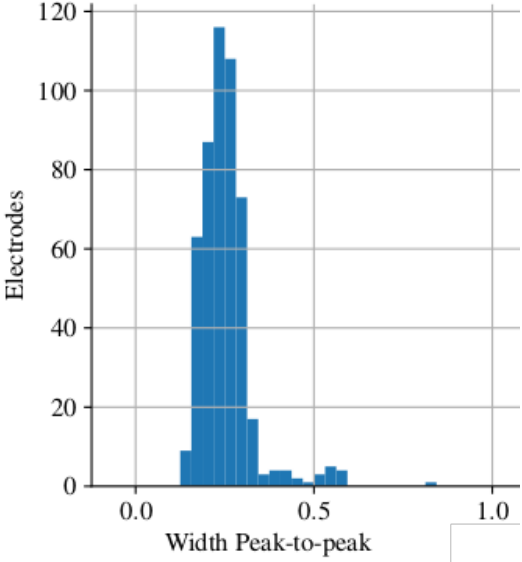
Blue Brain E-types



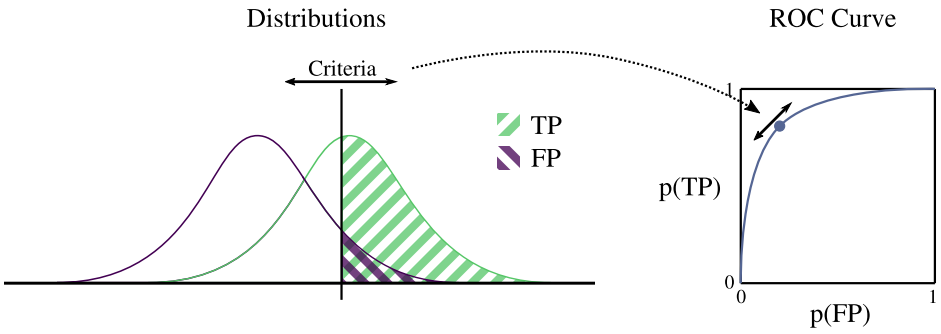
Placing Electrodes



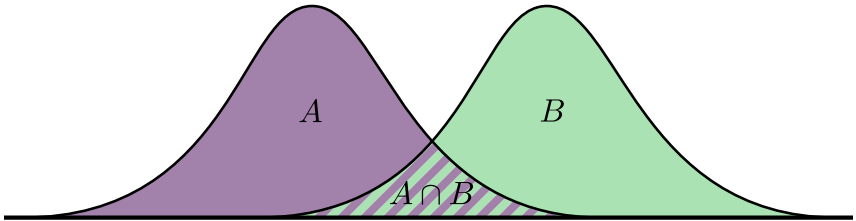
Histogram



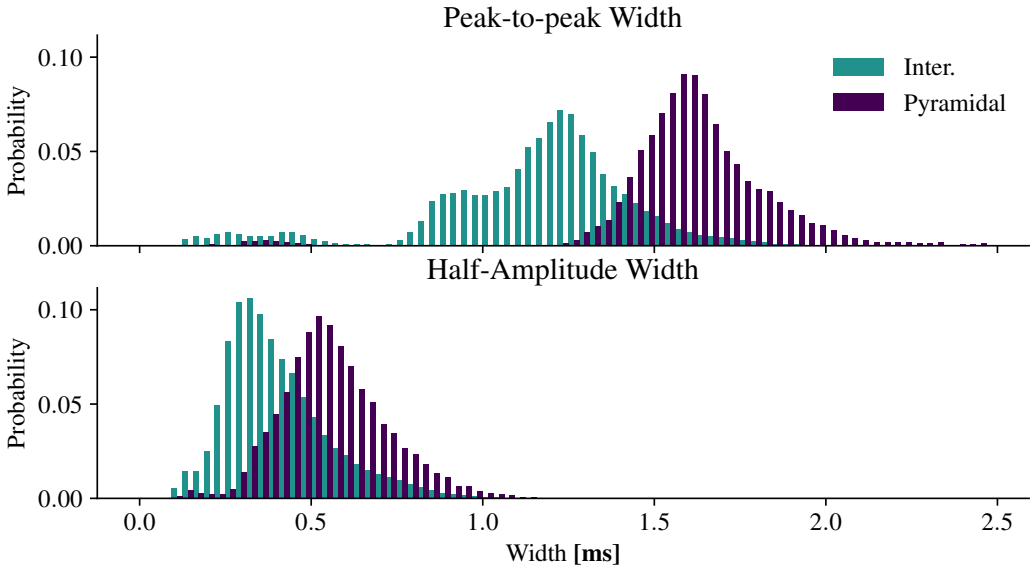
Histogram Comparison: ROC Curve



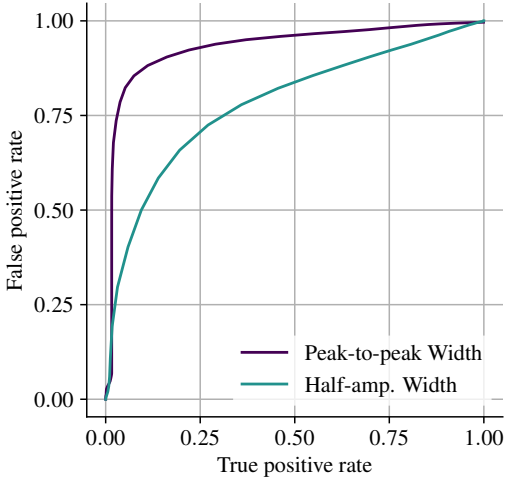
Histogram Comparison: Overlap



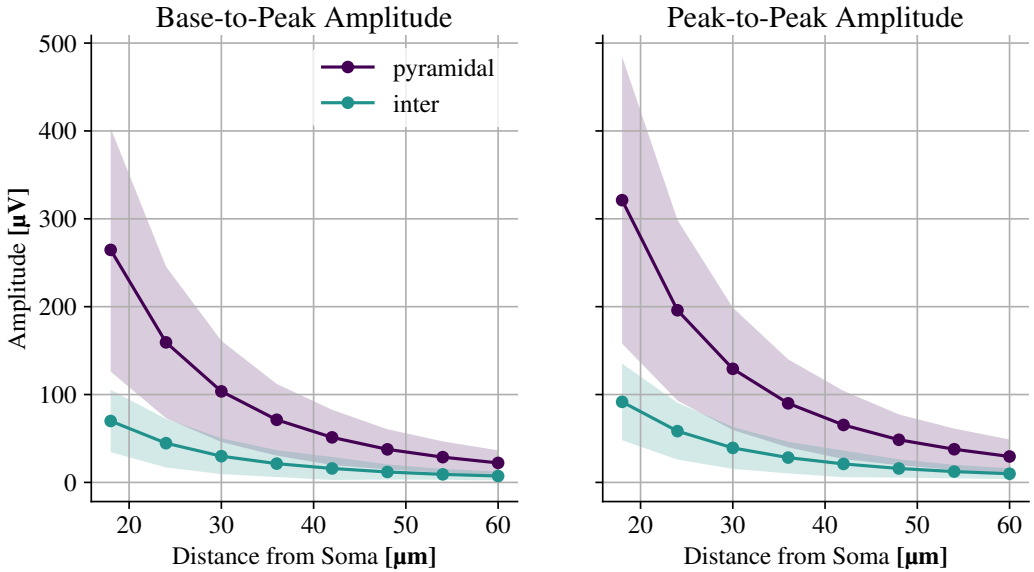
Choosing the Optimal Width Definition



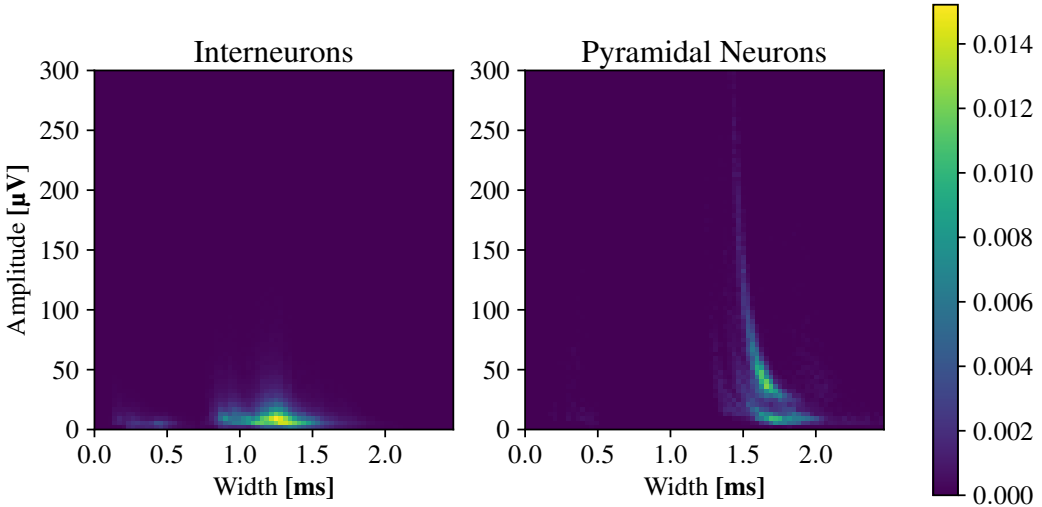
Choosing the Optimal Width Definition



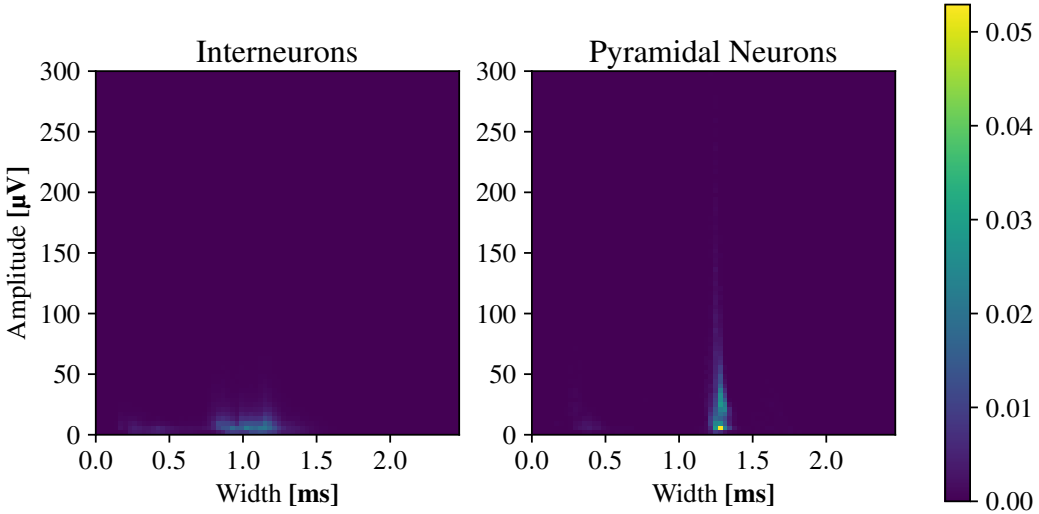
Choosing the Optimal Width Amplitude



Combining Spike Width and Amplitude



Effects of Filtering



Comparison to Other Sources

`www.neuroelectro.org`:

- A vide variance in neuroscience data.

Anastassiou et al 2015:

- A vide variance in neuroscience data.

Bartho et al 2004:

- A vide variance in neuroscience data.

Summary

Conclusion