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Adding Variations and Measuring Their Effects on Accuracy in LSM Neurons

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SRE Presentation

Guide: Prof. Udayan Ganguly

Establishing a ground plane

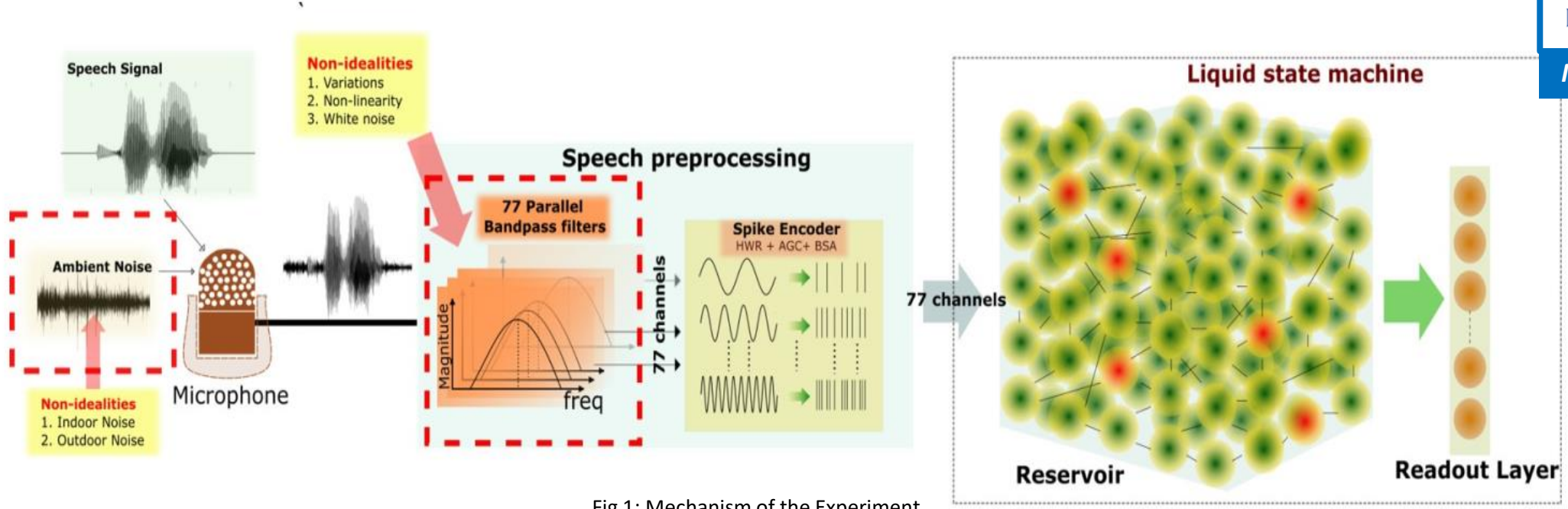

Fig 1: Mechanism of the Experiment

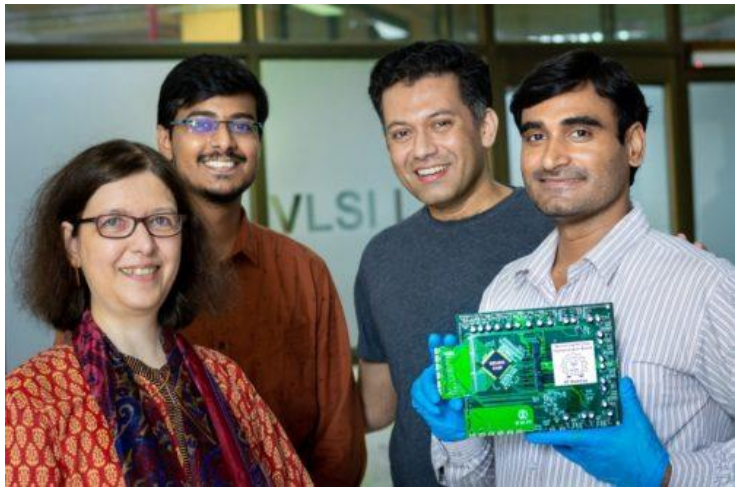

Fig 2: The design team behind the Neuro Chip(36 reservoir neurons)

Image credits: Fig 1: "Real-world Performance Estimation of Liquid State Machines for Spoken Digit Classification" – MeLoDe Lab IITB
Fig 2: ElectronicsForu.com "World's First SNN Developed at IIT Bombay"

What would the future look like?

The two very important graphs if viewed from a manufacturing perspective

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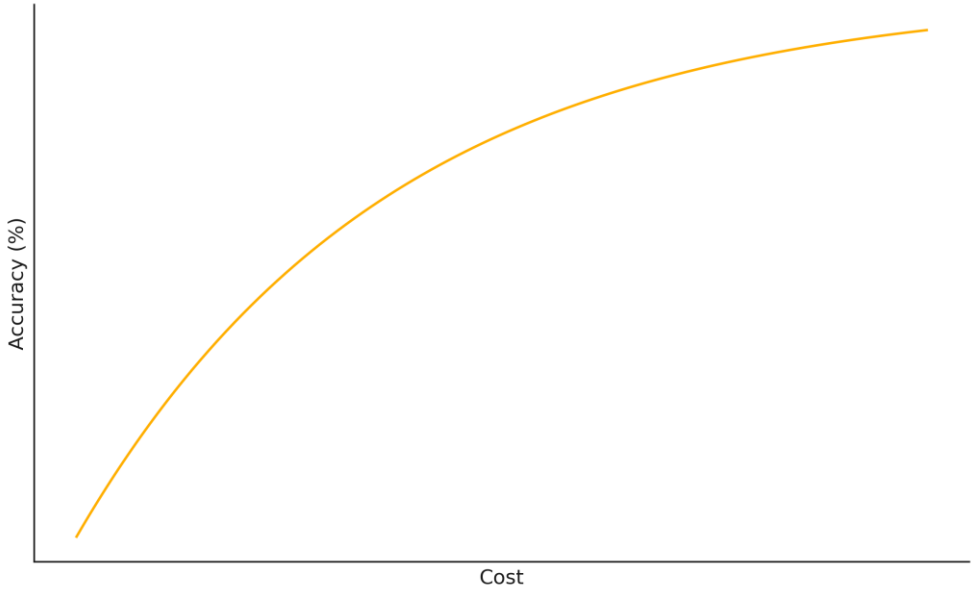

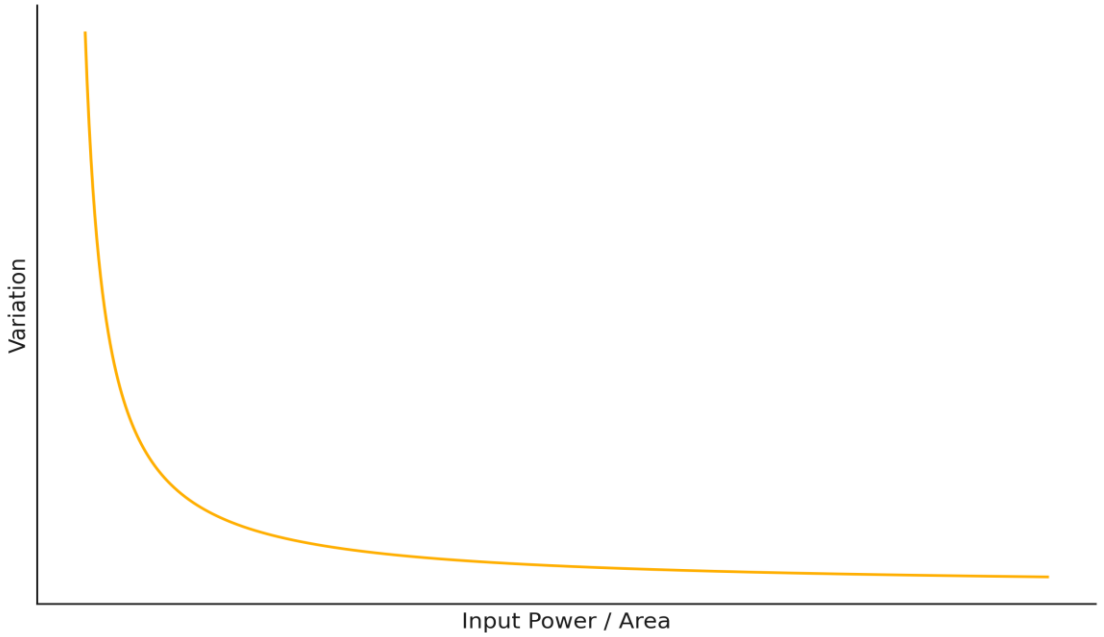

Fig 4, Fig 5: The two trade-offs that we need to counter to ship a reliable and cost friendly product

Image Credits: Fig 4,5: Me and Python

My Goal

- Currently the group is dealing with 125 neurons in the reservoir.

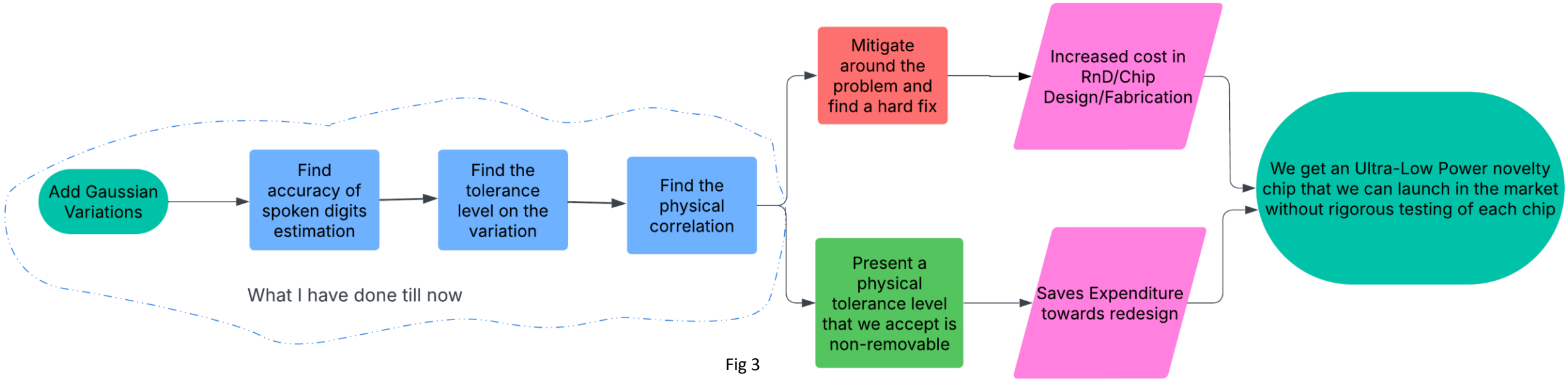

Fig 3

Credits Fig 3: Me via Lucidcharts

Neuronal Parameters

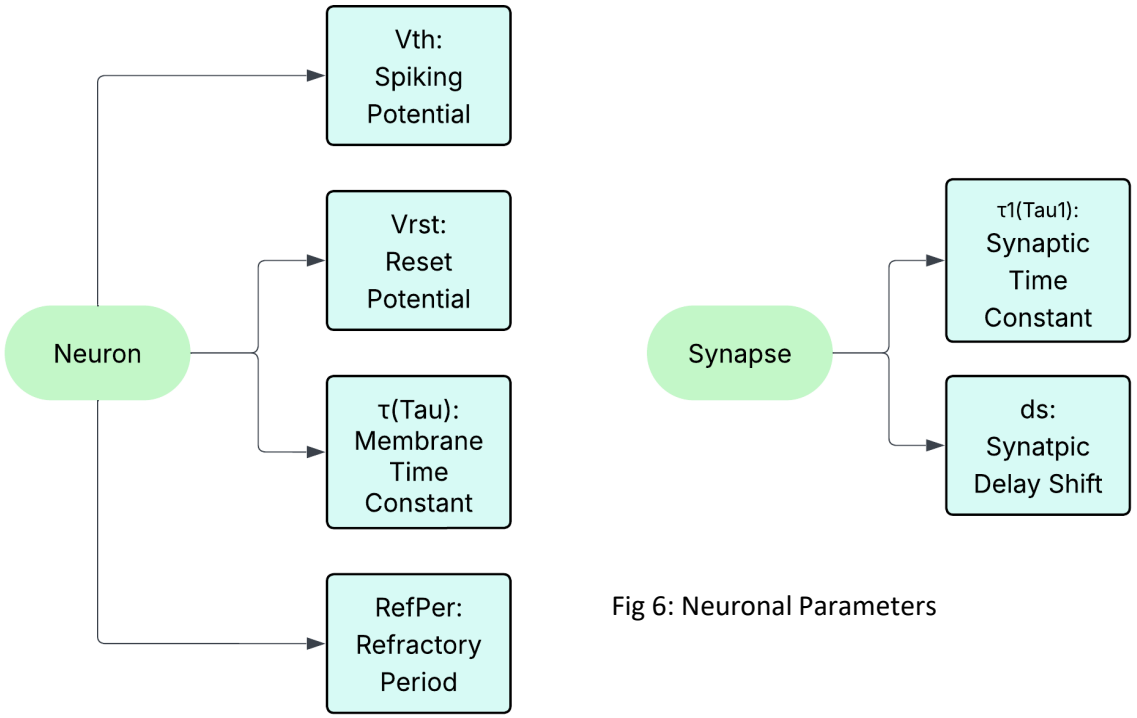

Fig 6: Neuronal Parameters

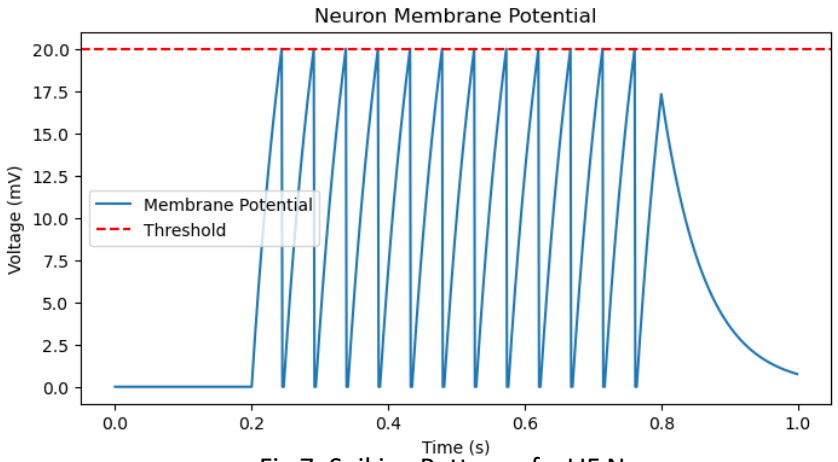

Fig 7: Spiking Pattern of a LIF Neuron

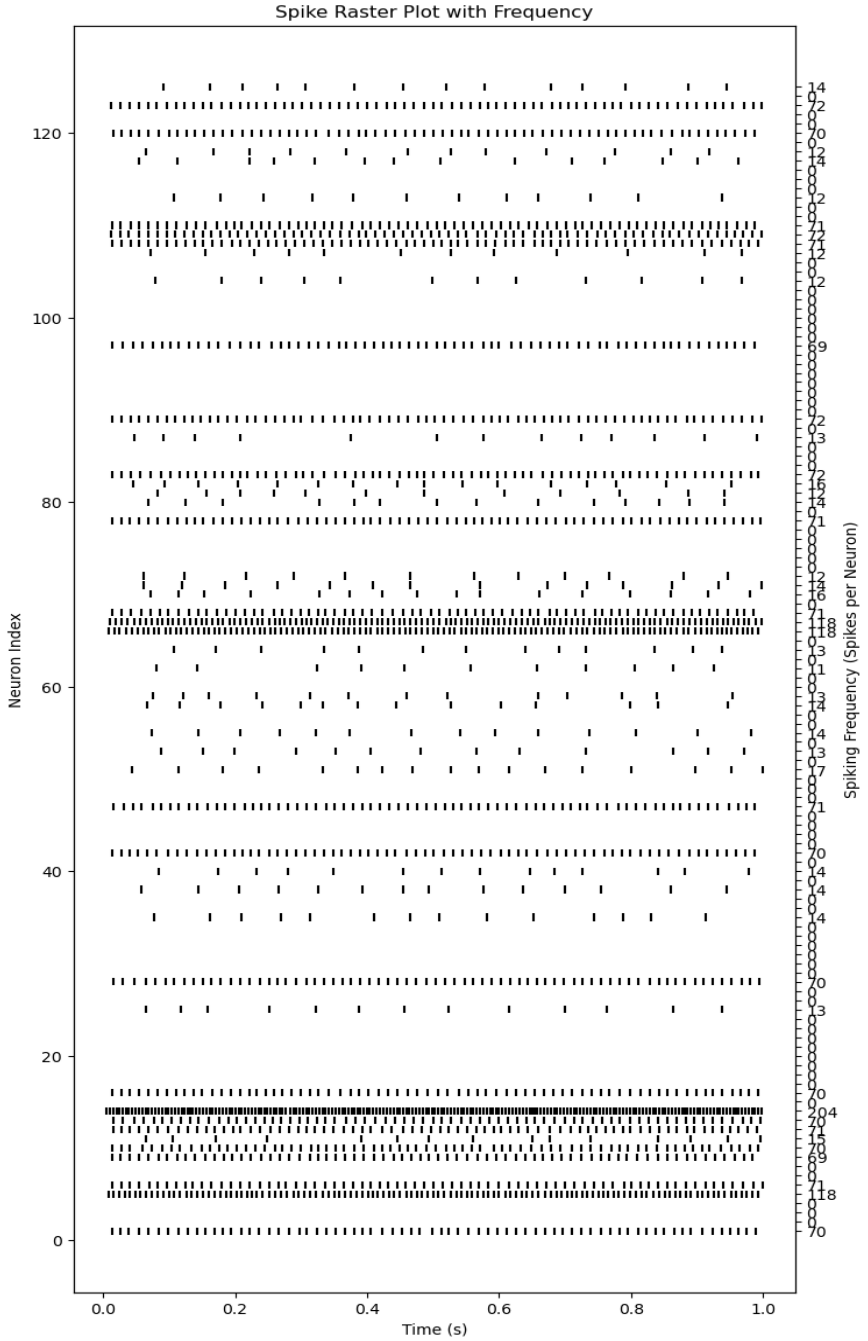

Fig 8: Varying Spiking frequency given varying input current

Image credits: Fig 6: Lucidchart and Me
Fig 7,8: Matplotlib and Me

The weight of the effect on accuracy

- Not every parameter affects the accuracy in the same range.

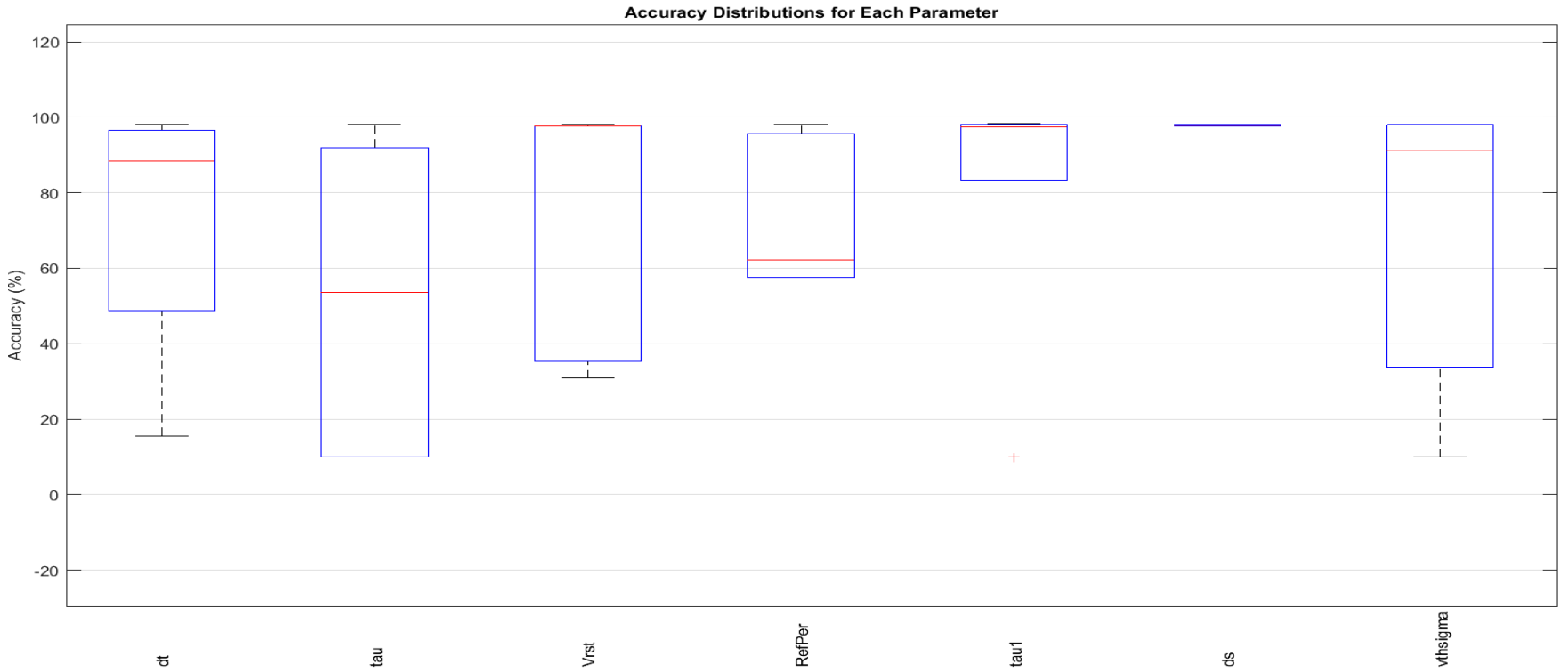

Fig 9: Plot representing the distribution of accuracy if the parameters are changed globally

- We can conclude that ds and τ1 do not contribute much and Vrst is basically ground. Hence they are not taken into consideration in further experiments.

Image Credits: Fig 9: Me and Matlab

Design of Experiment/Process Flow

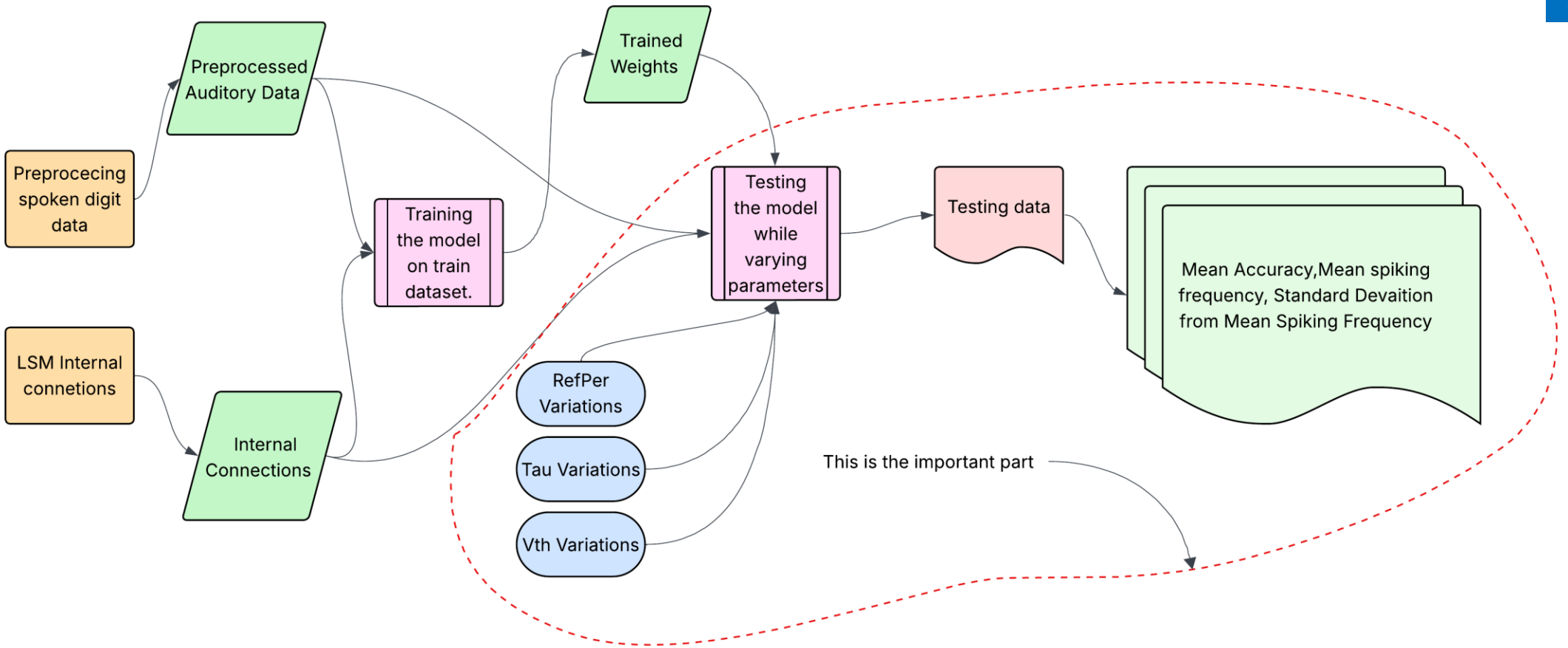

Fig 10: Process flow of the experiment

Image Credits: Fig 10: Me and Lucidchart

How are the variations modelled?

- The baseline values of the parameters are:

Parameter	Baseline Value (μ_X)
Vth	20mV
Refractory Period	2mS
Membrane Time Constant	64ms

- We define variability as "σ/μ".

  And for every neuron '*i*' in the reservoir, the parameter X_i varies as follows:

$$X_i = \mu_X + (\sigma/\mu)*(\mu_X)*N(0,1)$$

  where μ_X is the baseline value of the parameter, and $N(0,1)$ is a standard normal variable.

Results

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Vth Variations

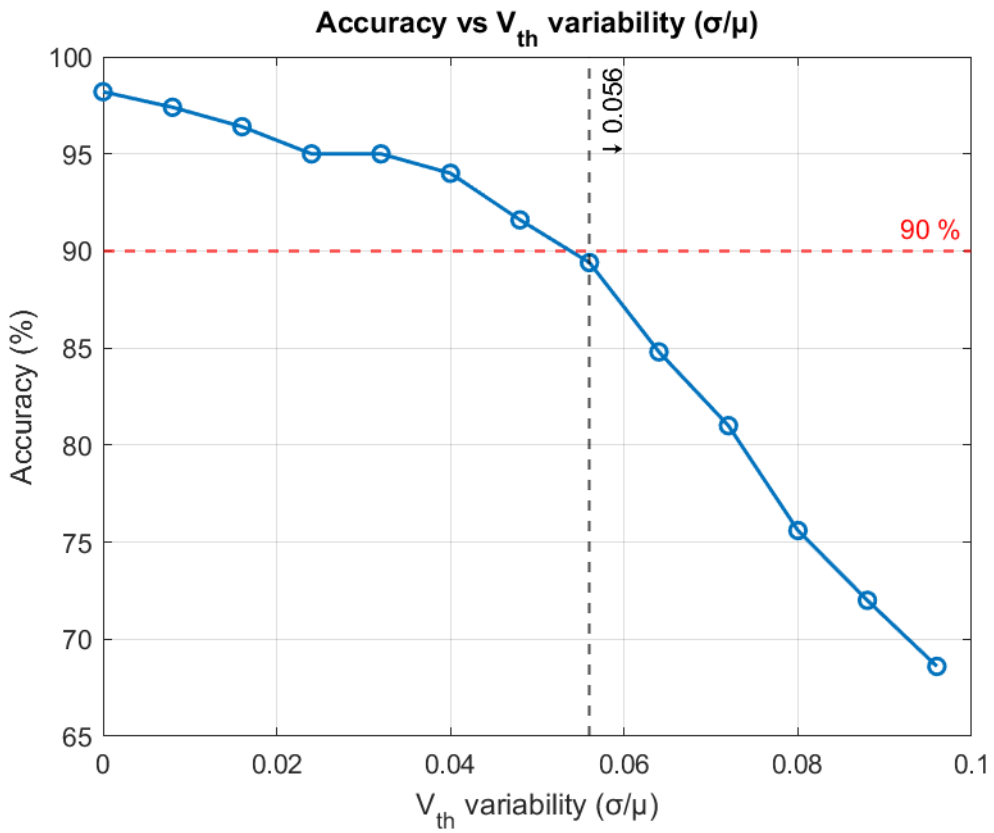

Fig 11

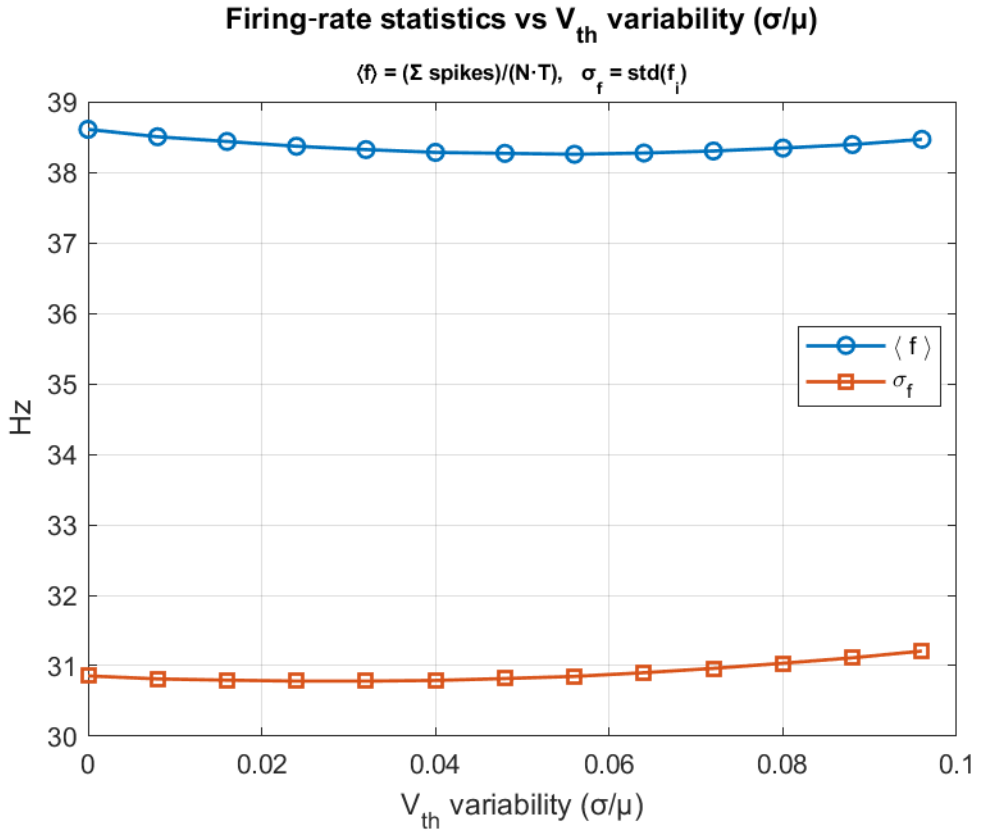

Fig 12

Image Credits: Me and Matlab

Results

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Refractory Period Variations

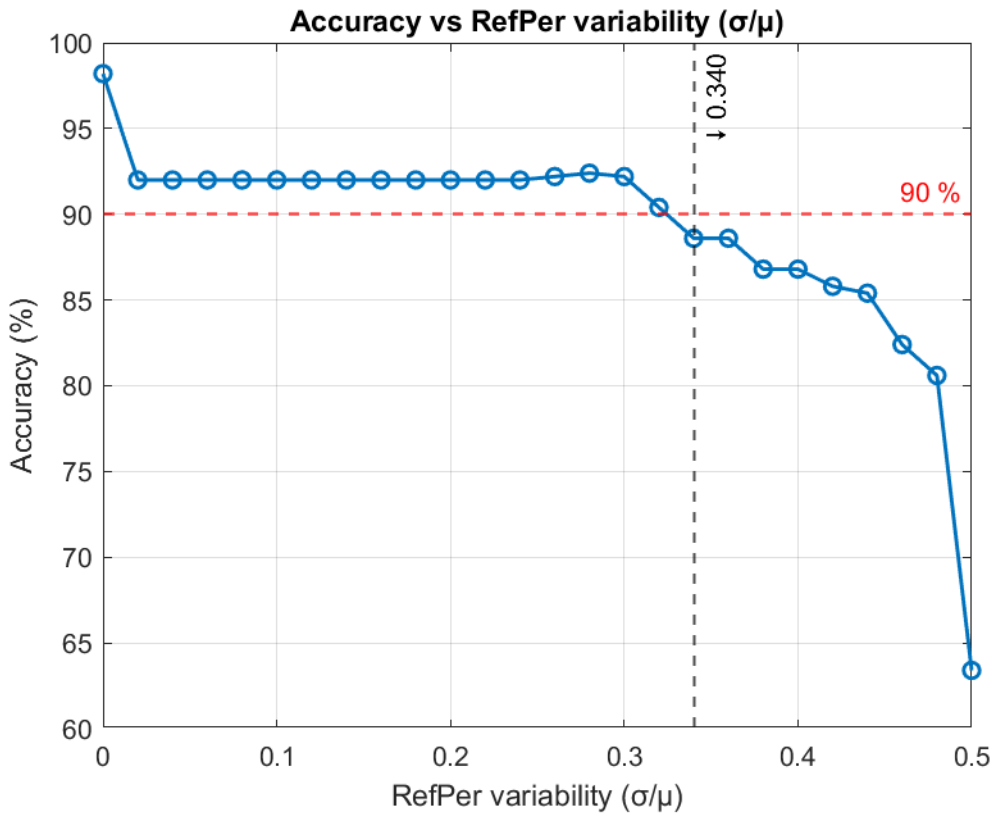

Fig 13

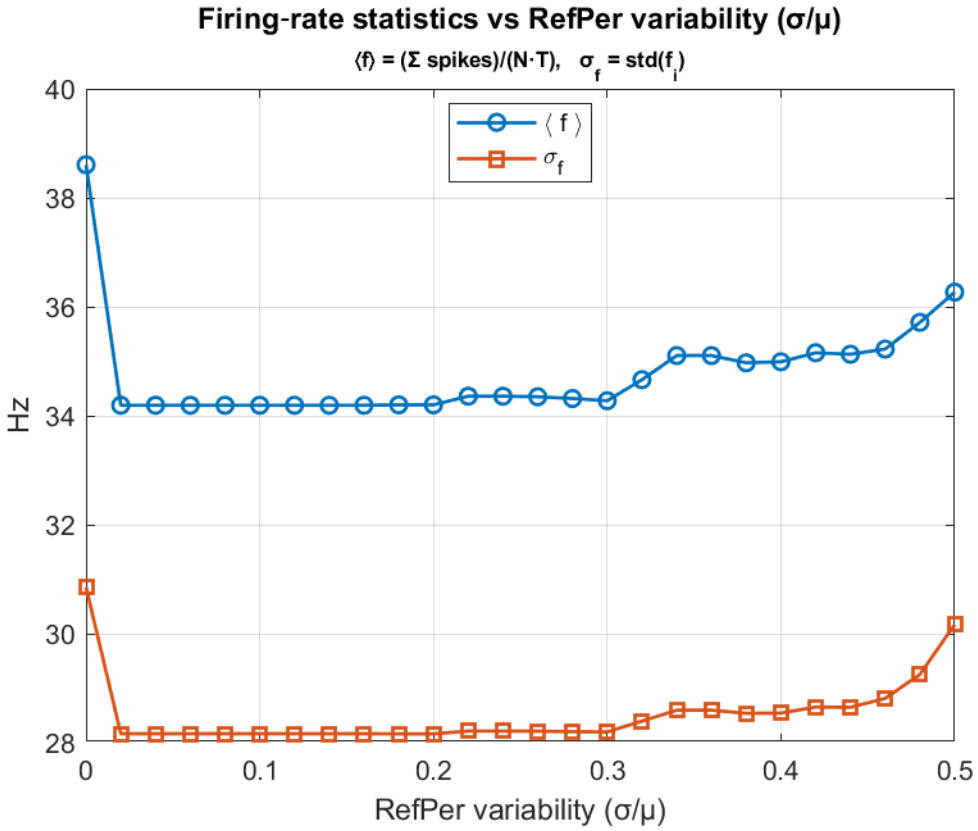

Fig 14

Image Credits: Me and Matlab

Results

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Membrane Time Constant Variations

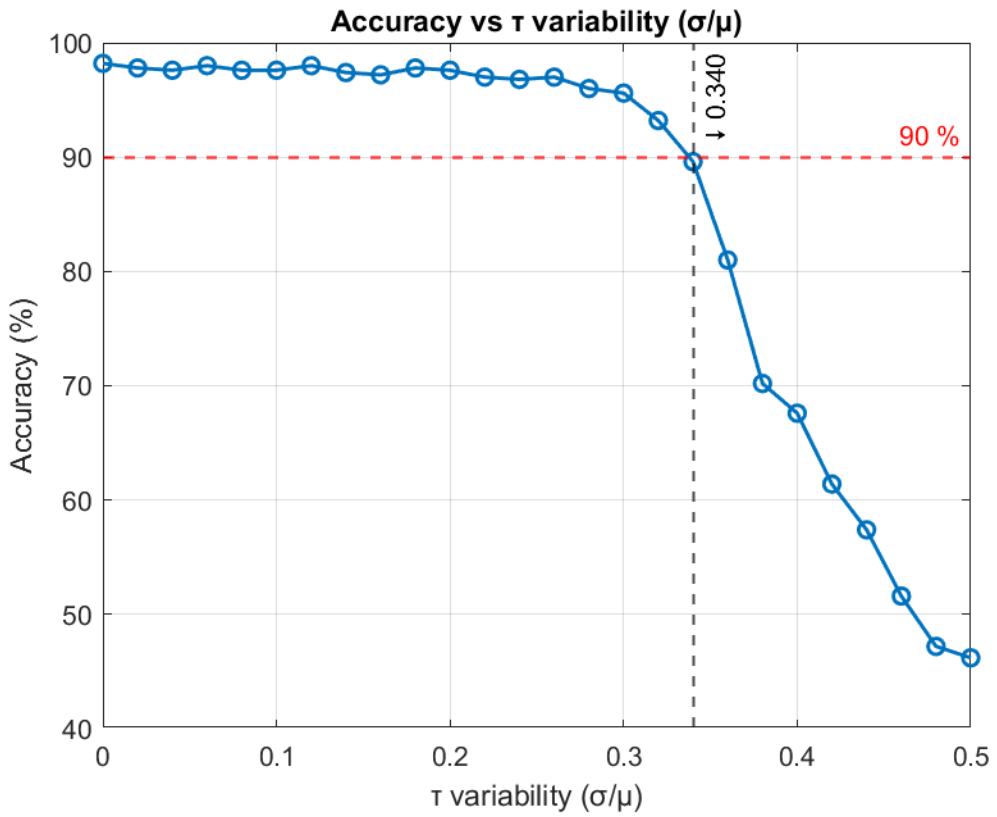

Fig 15

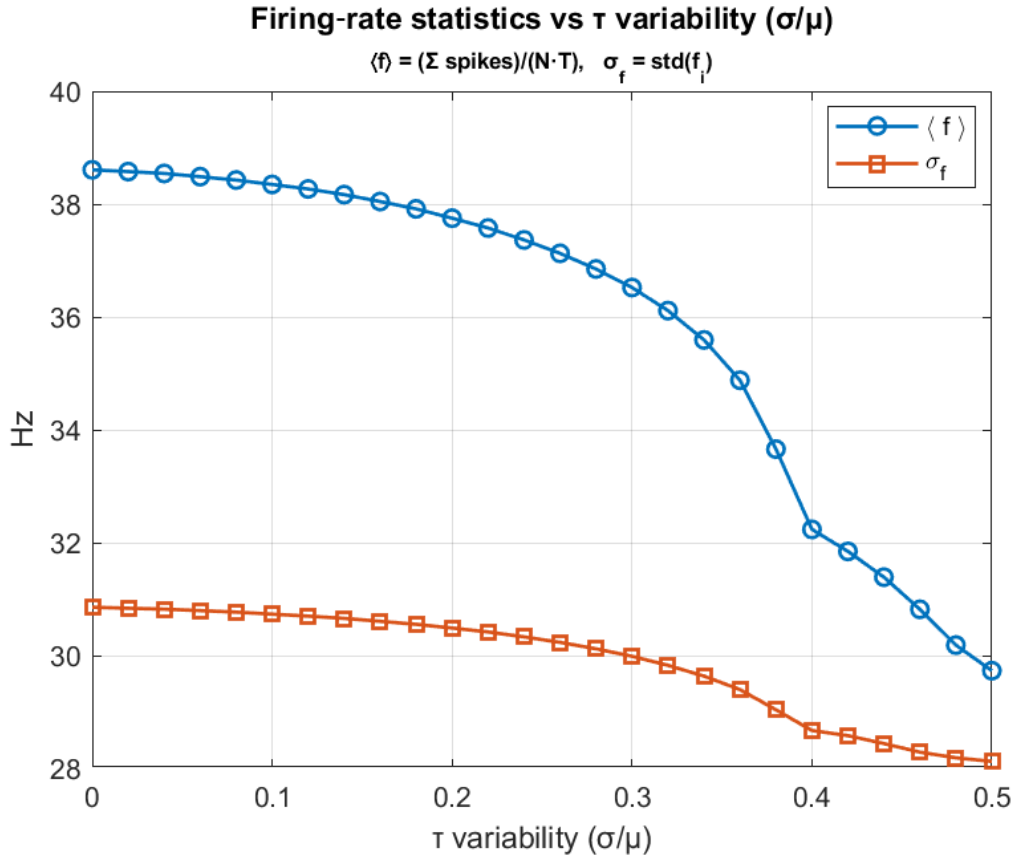

Fig 16

Image Credits: Me and Matlab

Tolerance Values Measured Algorithmically

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Parameter	Variability (σ/μ)
Vth	0.056
Refractory Period	0.340
Membrane Time Constant	0.340

Physical Correlation of the observations

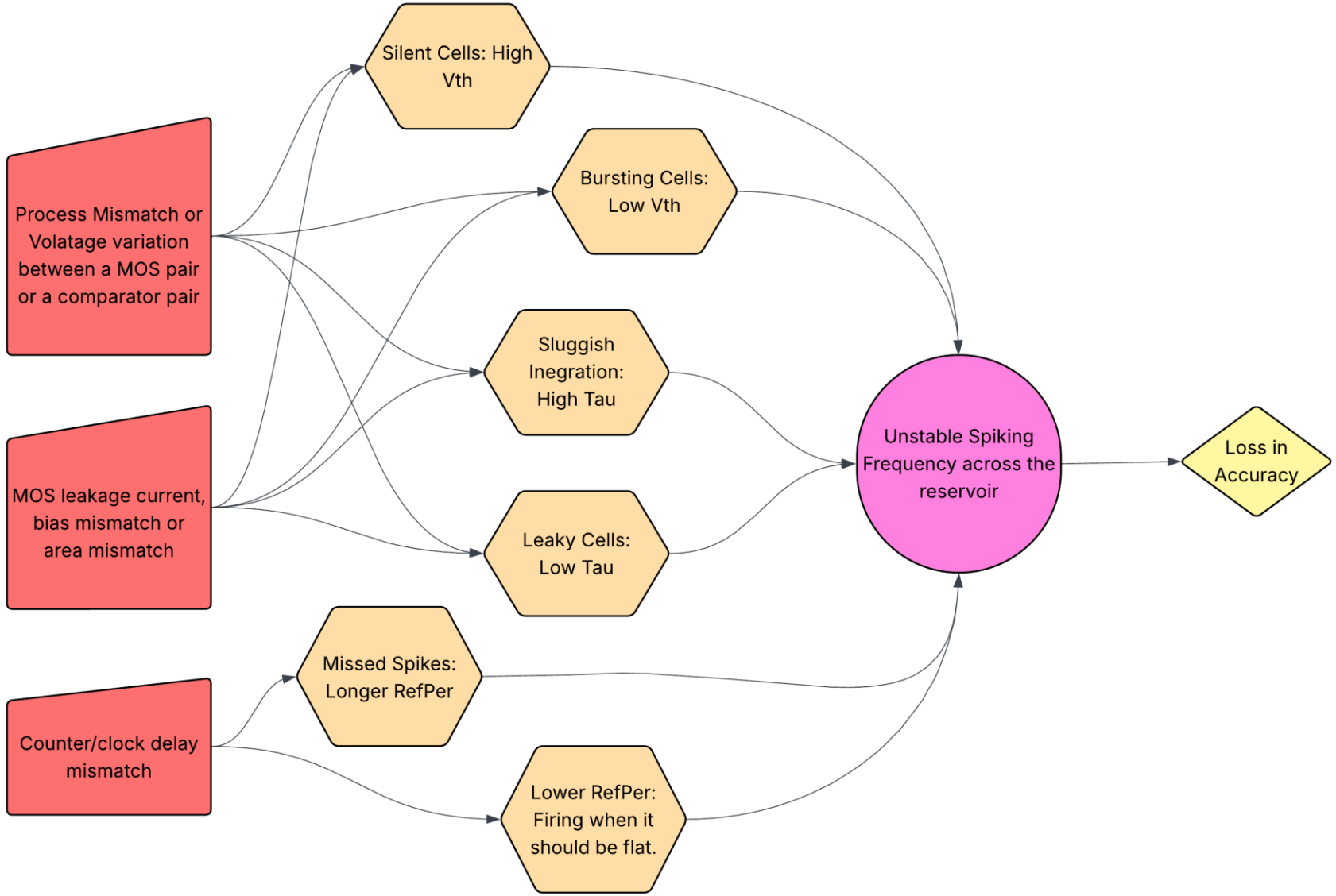

Image Credits: Me and Lucidchart

What's Next?

- Discussions with the Circuits team concerning the problems that need to be tackled.

- Finding the intersection point of Cost vs Input Power vs Accuracy and then working forward towards design and manufacturing.

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Thank You!!