

Leveraging NVMs for Neural Interface Coverage

Muhammed Ugur, Raghavendra Pradyumna Pothukuchi,
Abhishek Bhattacharjee

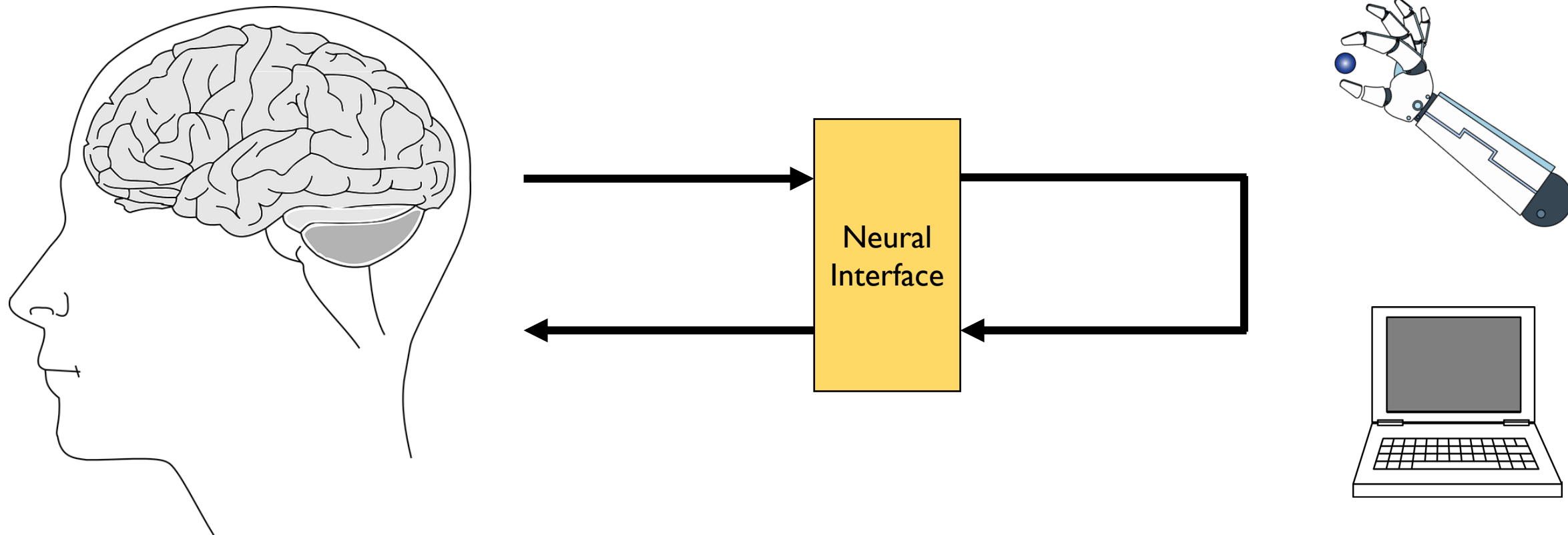
The Yale University logo, consisting of a dark blue right-angled triangle with the word "Yale" in white serif font centered within it.

Yale

Neural Interfaces and NVMs

What are Neural Interfaces?

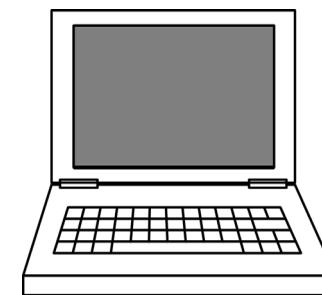
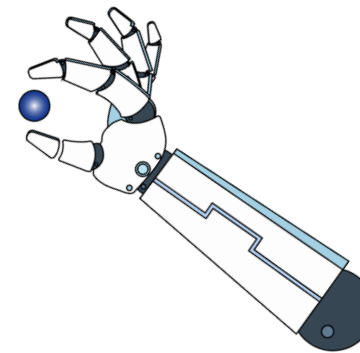
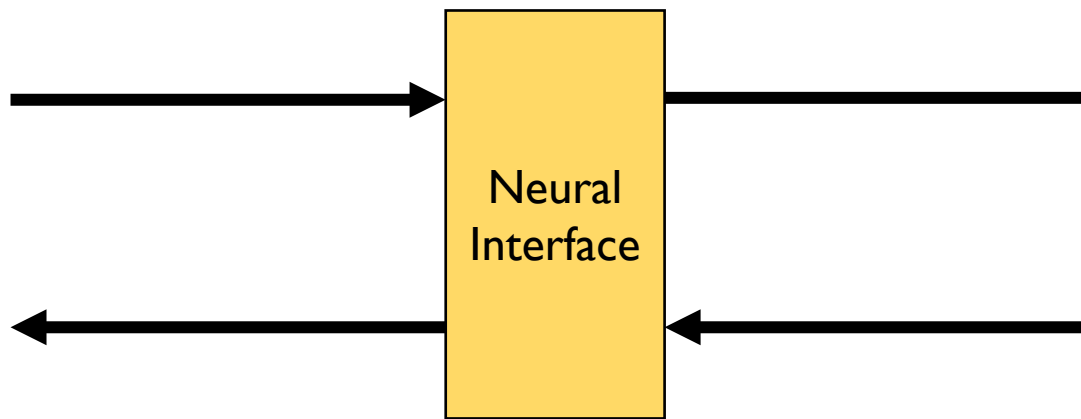
Neural Interfaces



Neural Interfaces



Read Neural Activity



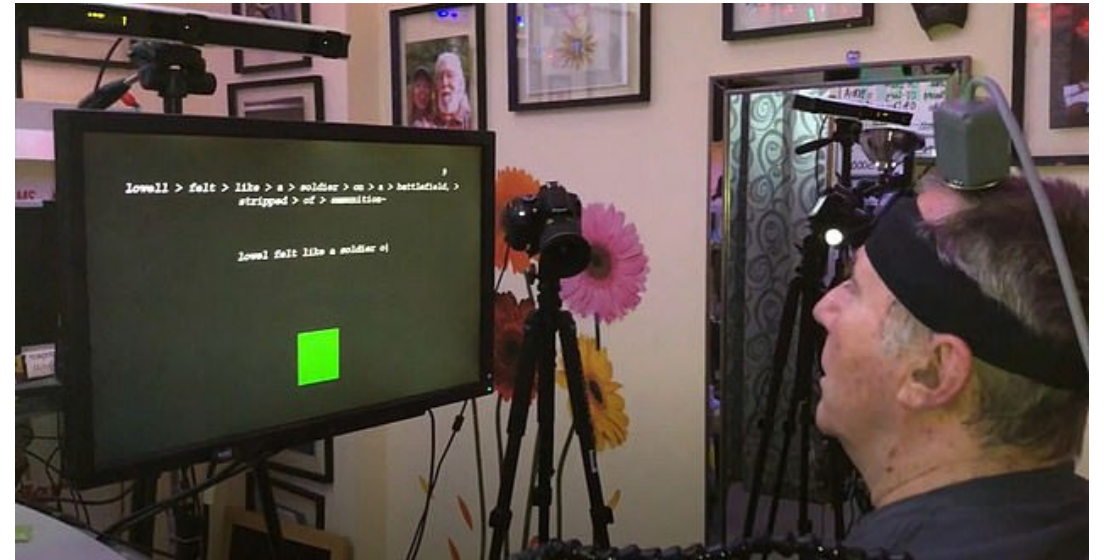
Provide Treatment

Clinical Uses

Assistive Movement and Communication



The BrainGate Collaboration, Brown University, Mass General



Willet et al., Stanford University

Many More Uses

The New York Times

A 'Pacemaker for the Brain': No Treatment Helped Her Depression — Until This

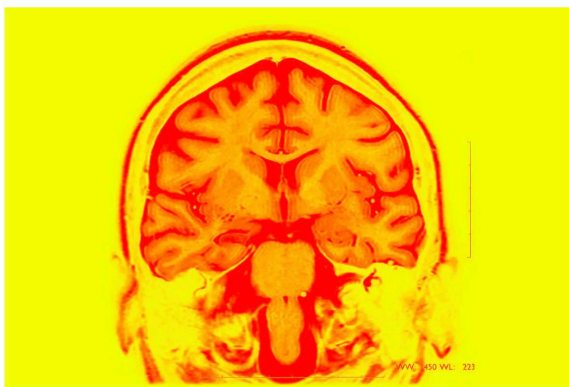
It's the first study of individualized brain stimulation to treat severe depression. Sarah's case raises the possibility the method may help people who don't respond to other therapies.

A Brain Implant Improved Memory, Scientists Report

Give this article



12



A magnetic resonance image of an epileptic brain. Scientists have tested a brain implant on people with epilepsy that aided memory. Bsp/UiG, via Getty Images

Brain Implants Allow Paralyzed Man to Walk Using His Thoughts

In a new study, researchers describe a device that connects the intentions of a paralyzed patient to his physical movements.



FDA-approved Devices for Epilepsy, Parkinson's, Multiple Sclerosis, Dystonia

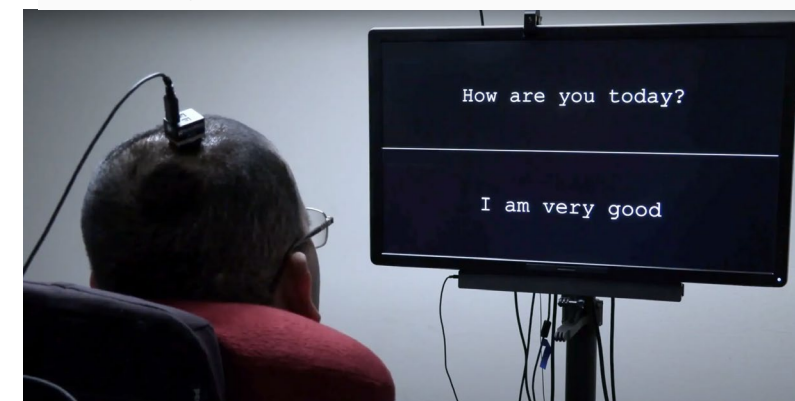
HEALTHCARE

Brain Implants With The Potential To Restore Vision To The Blind

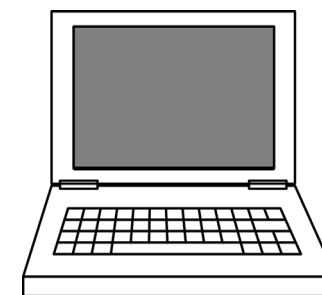
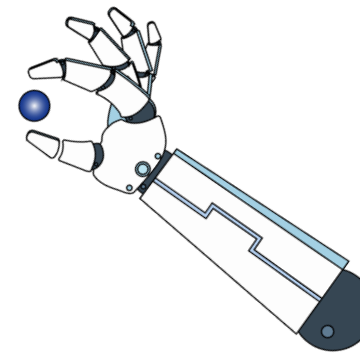
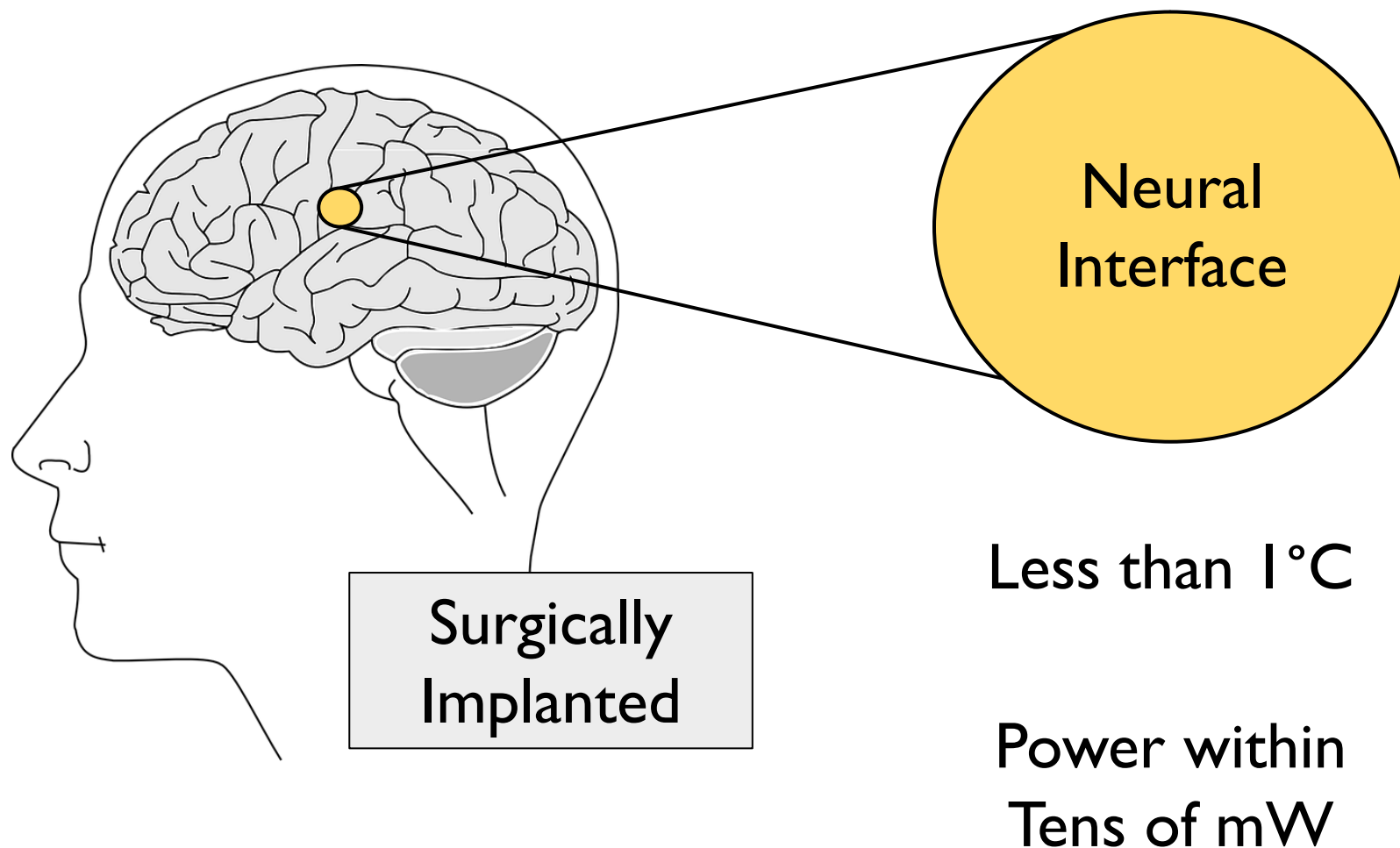
William A. Haseltine Contributor

Follow

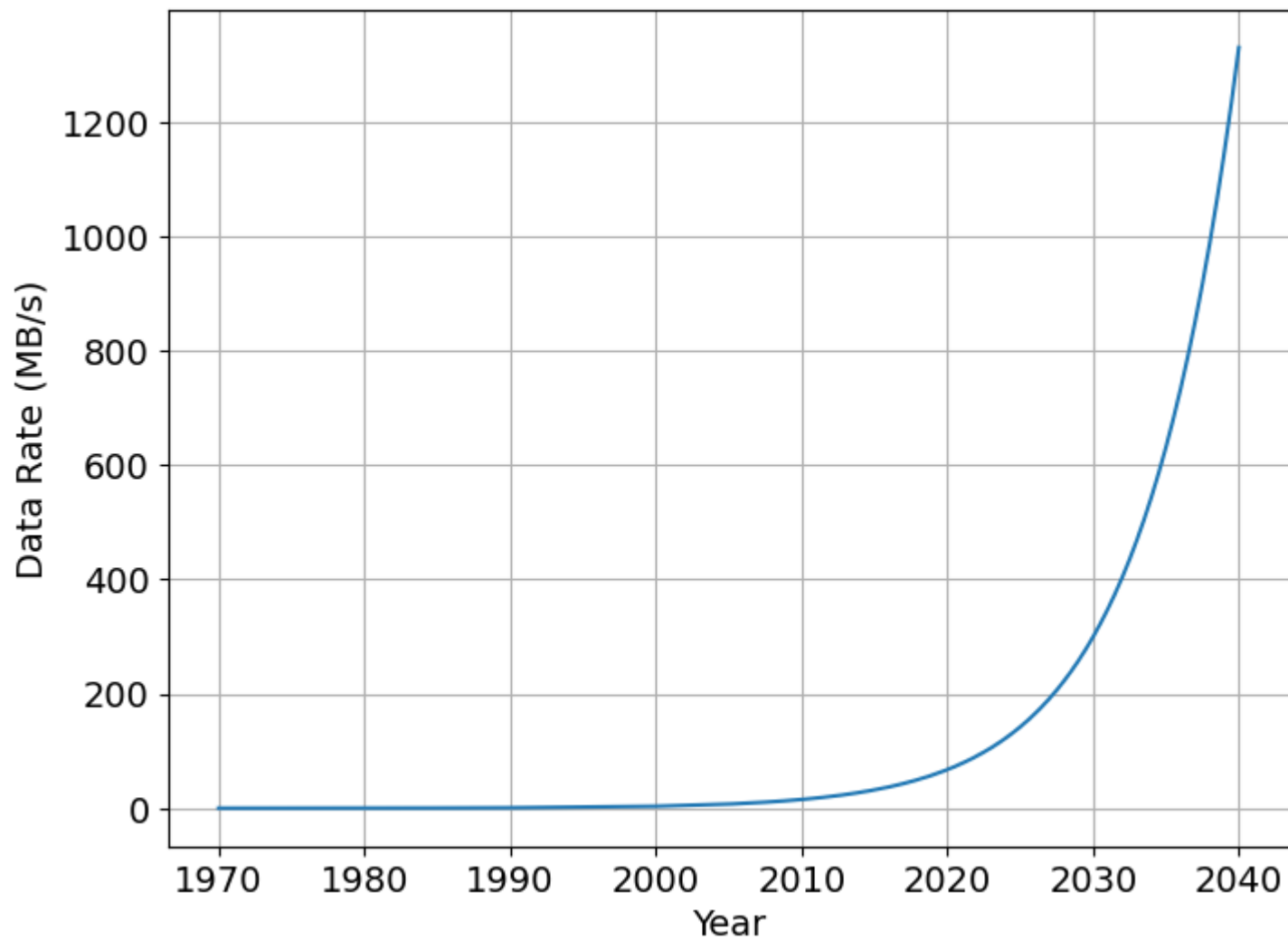
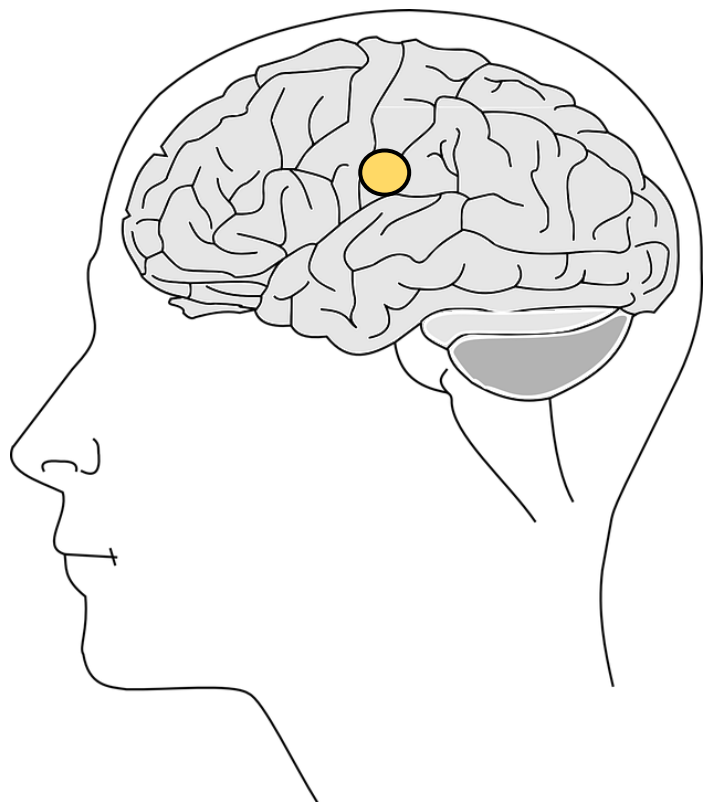
Nov 5, 2021, 12:24pm EDT



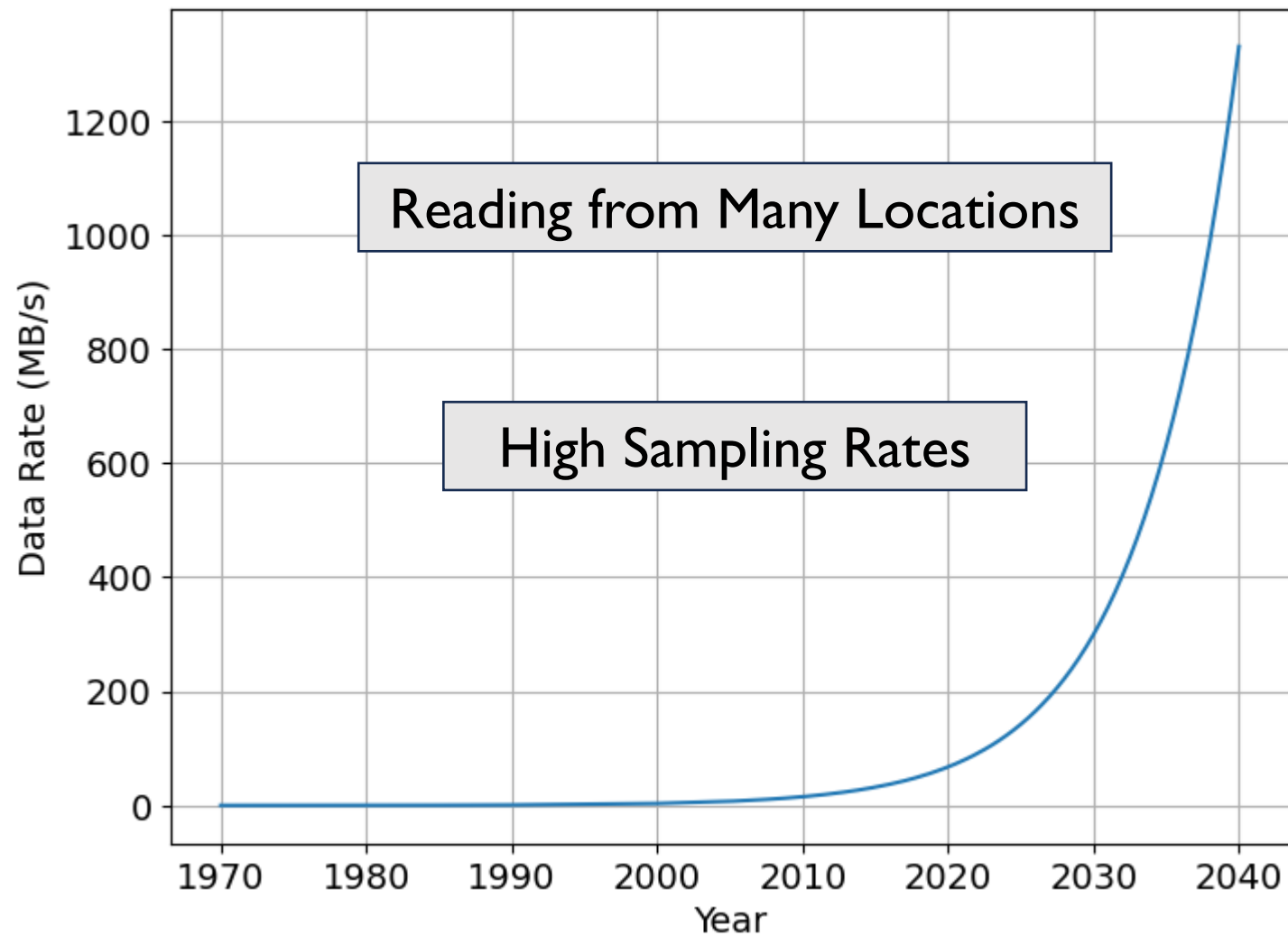
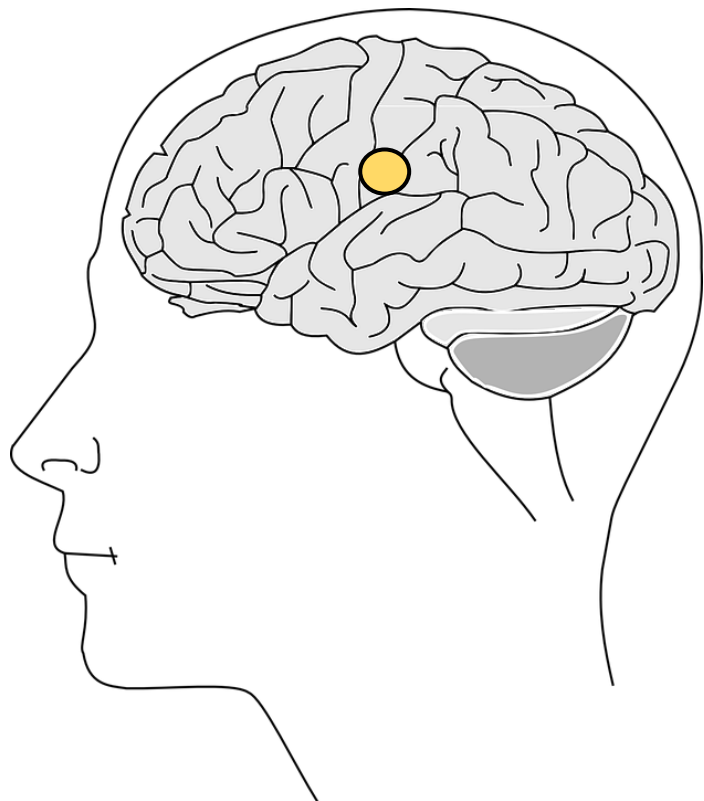
Safety and Implantation



Data Volume



Data Volume

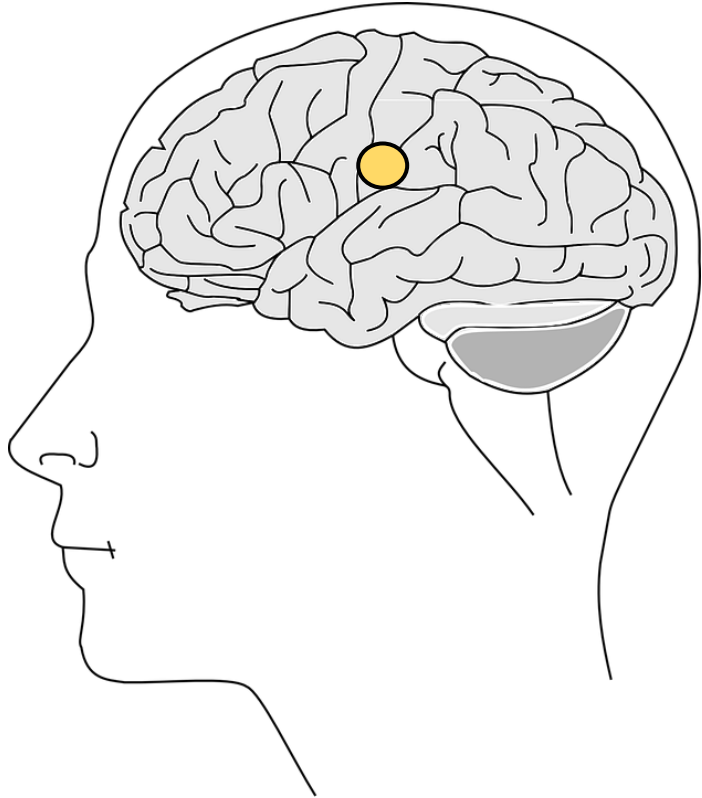


Benefits of Data Volume

Difference between Coarse-grained vs. Fine-grained Movements



System Requirements

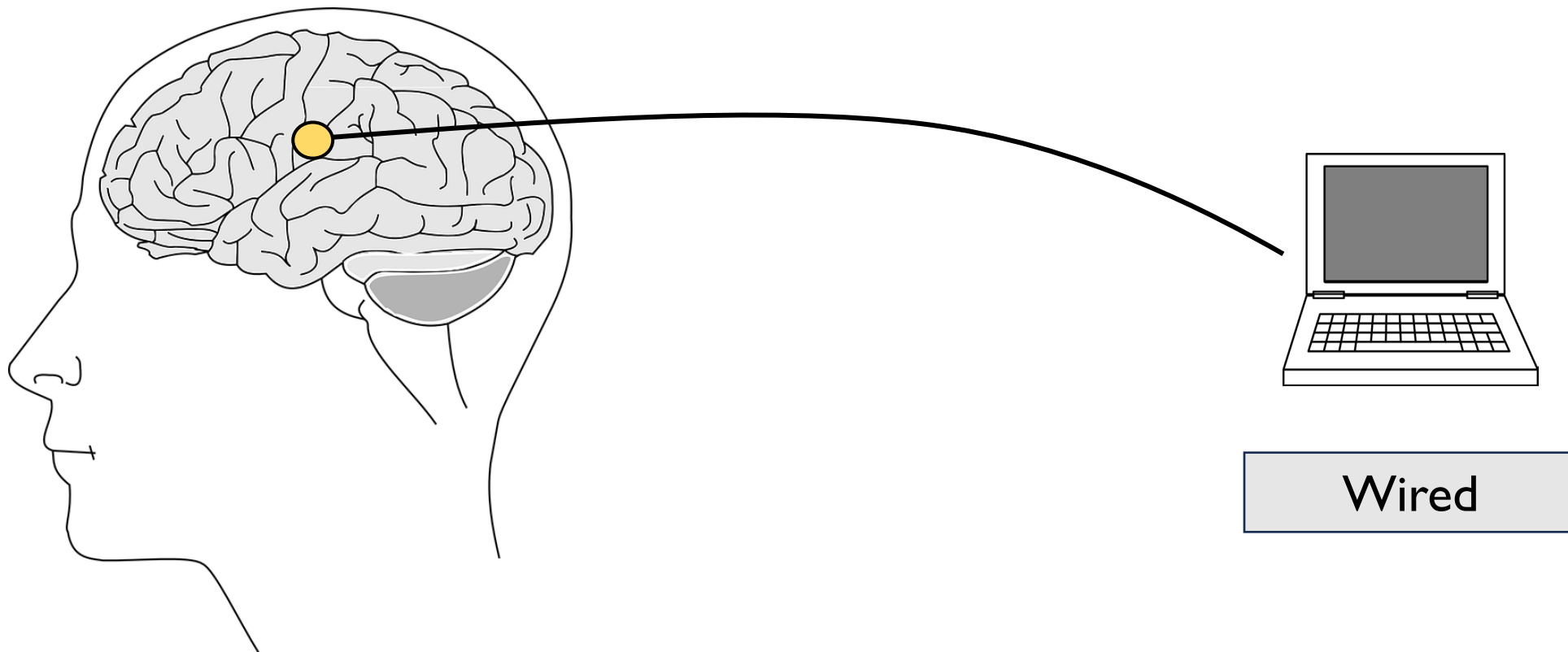


High Data Rates

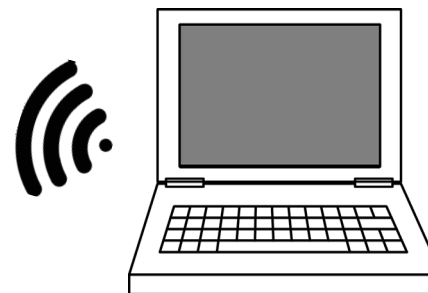
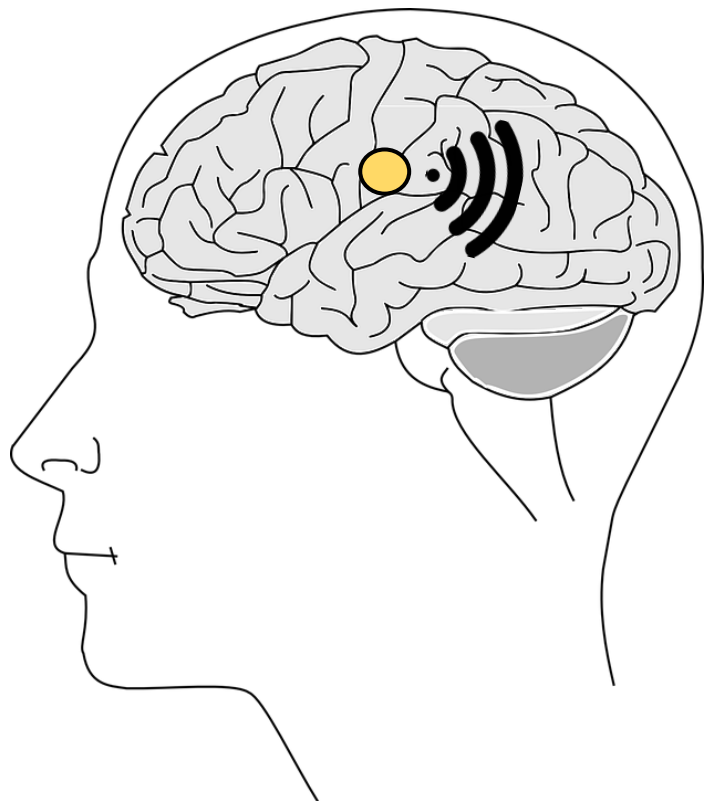
Power within Tens of mW

Real-Time Processing

Wired Options

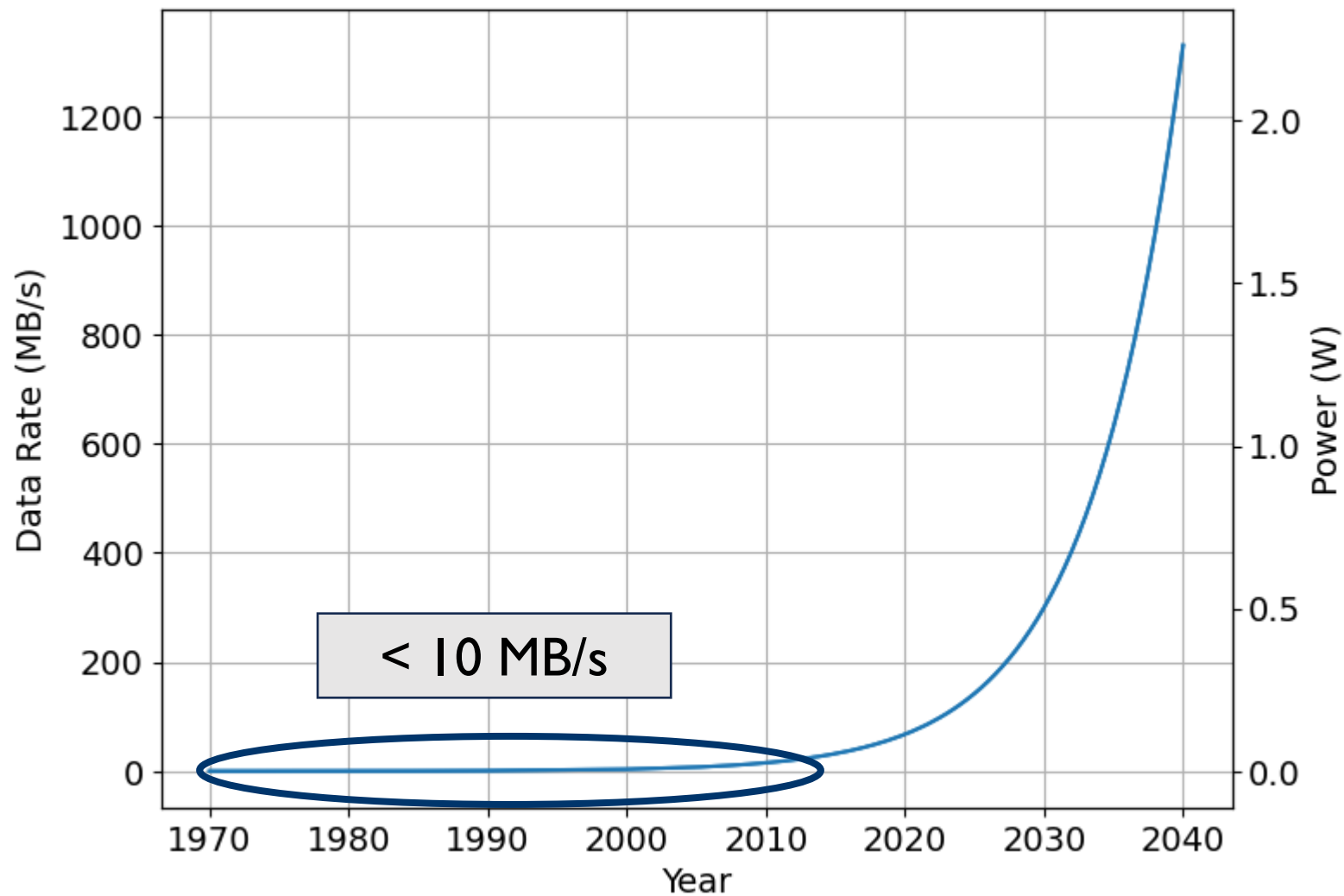
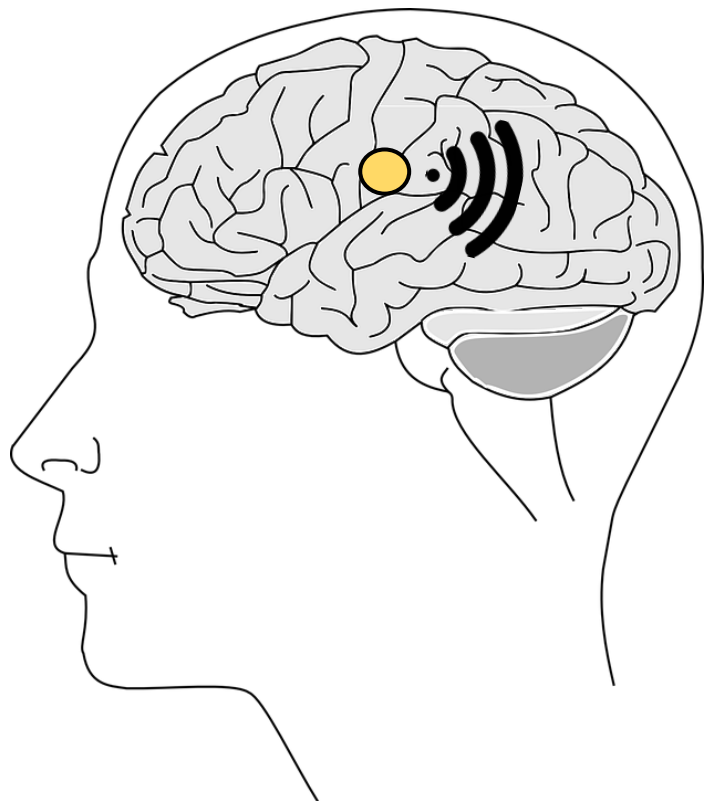


Wireless Options

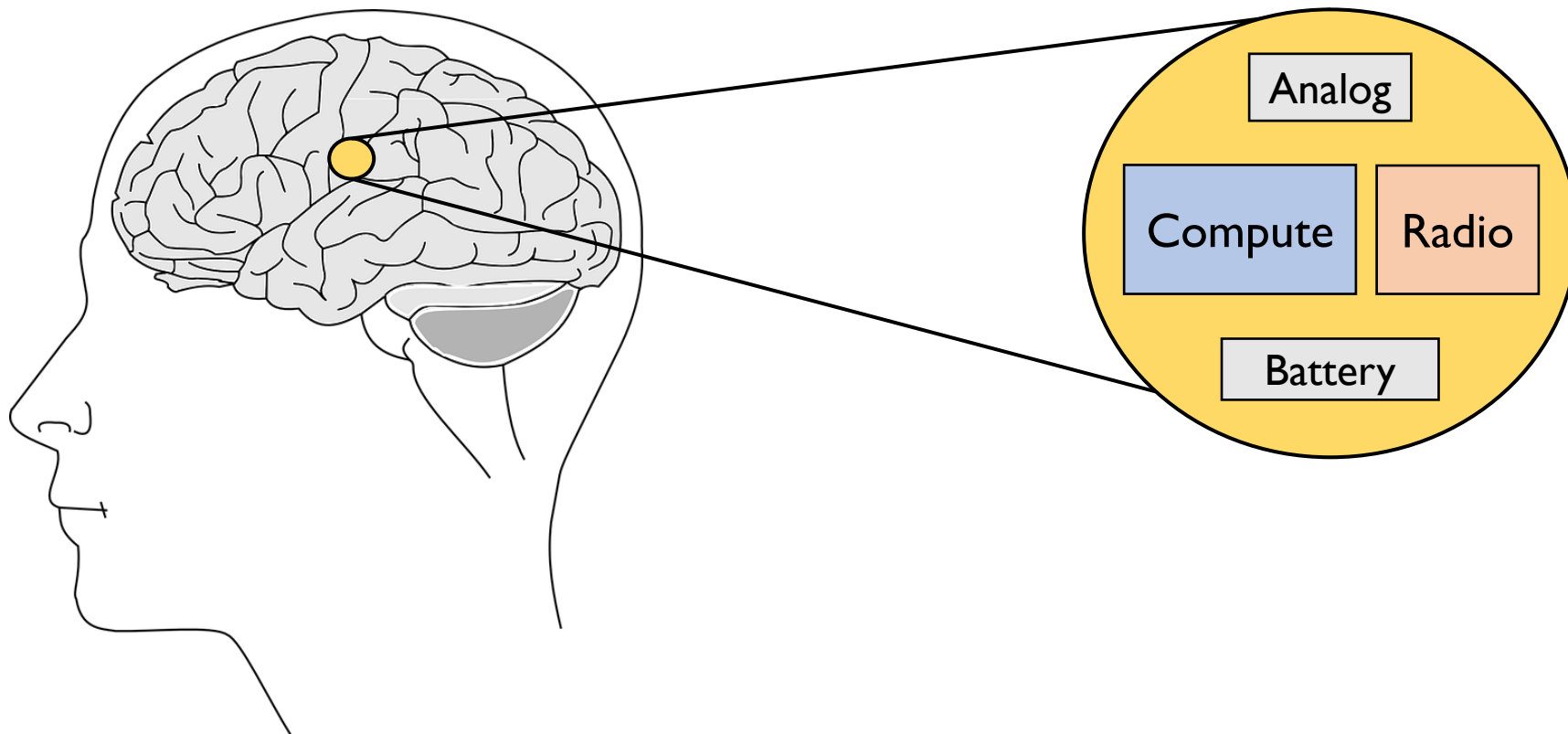


Wireless

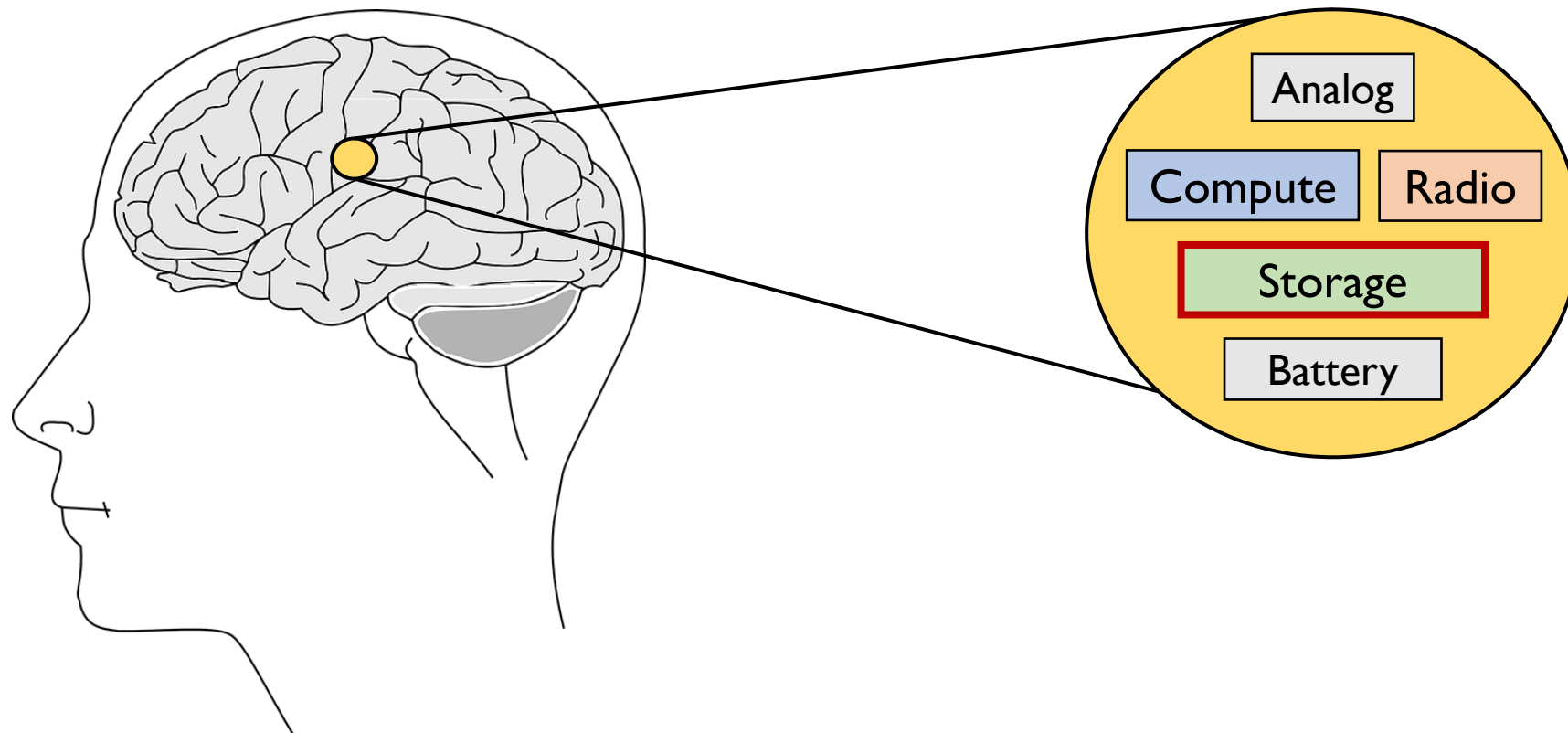
Power Limits Bandwidth



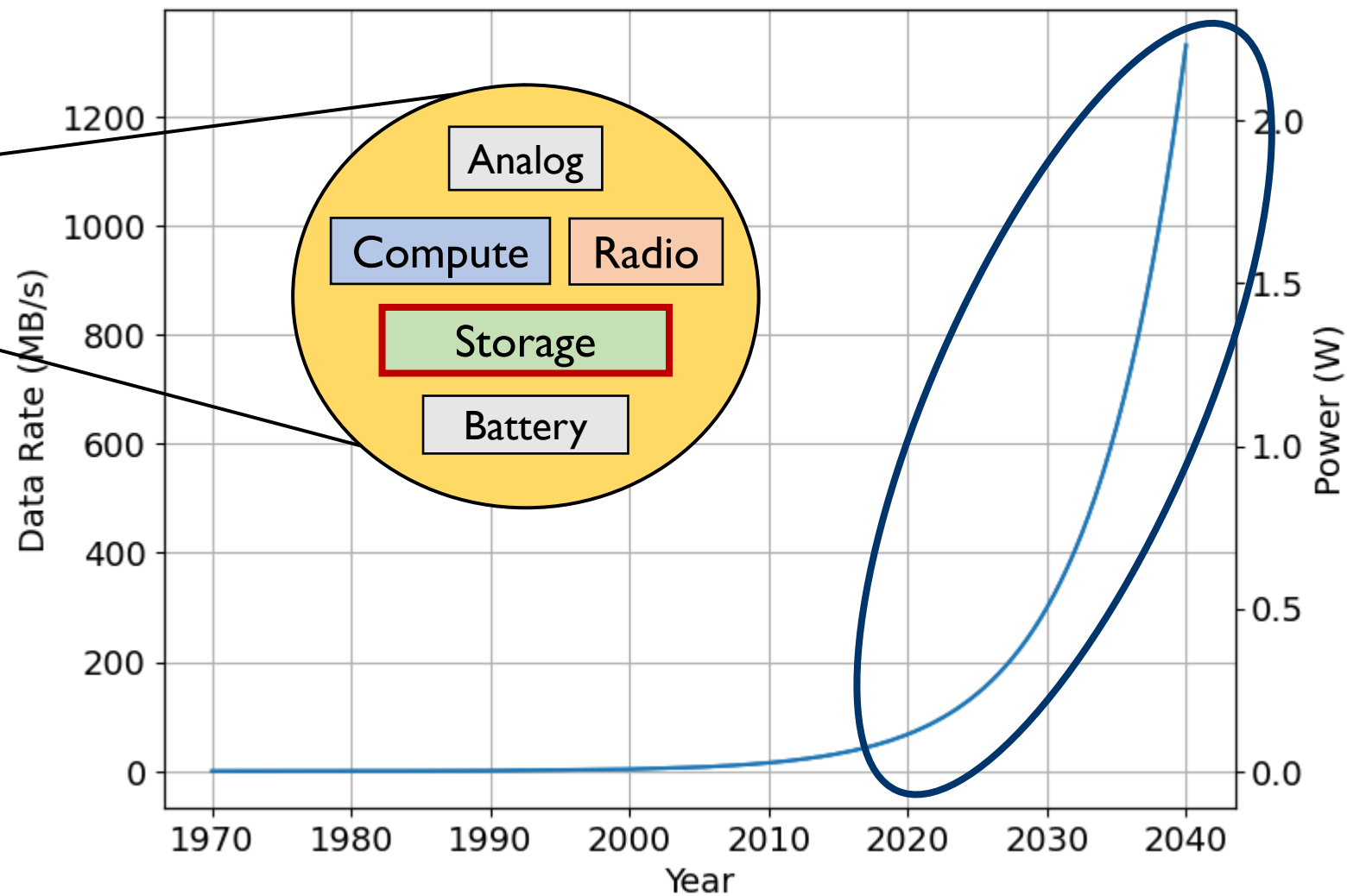
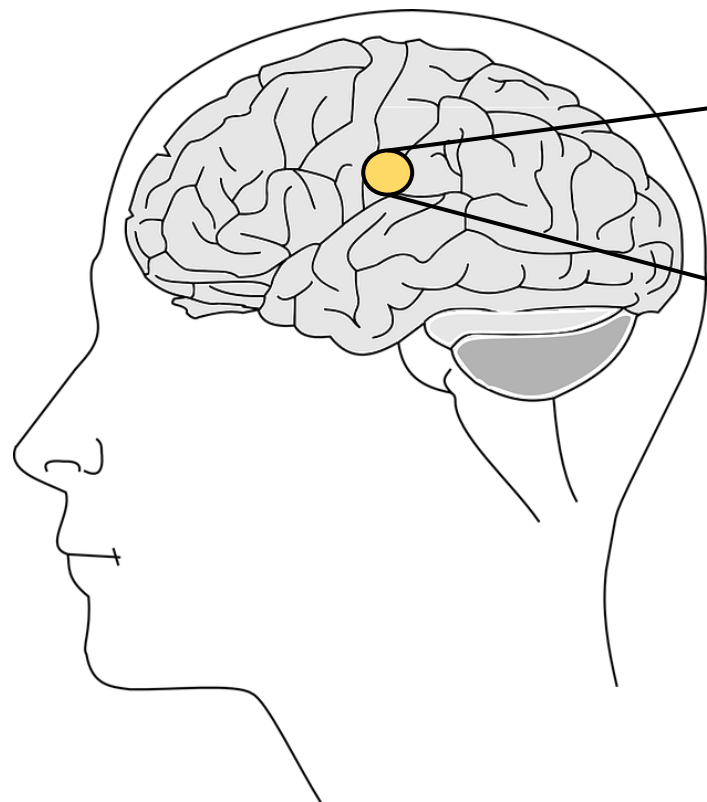
On-Device Processing



On-Device Storage



On-Device Storage



Existing Systems



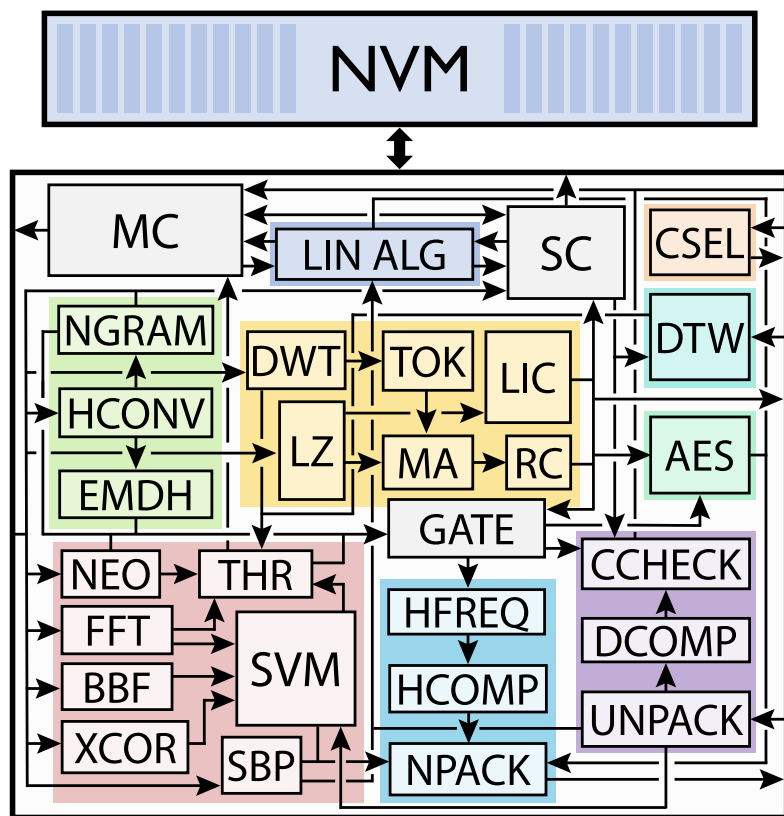
NeuroPace RNS

1 MB Storage

~10 Kbps

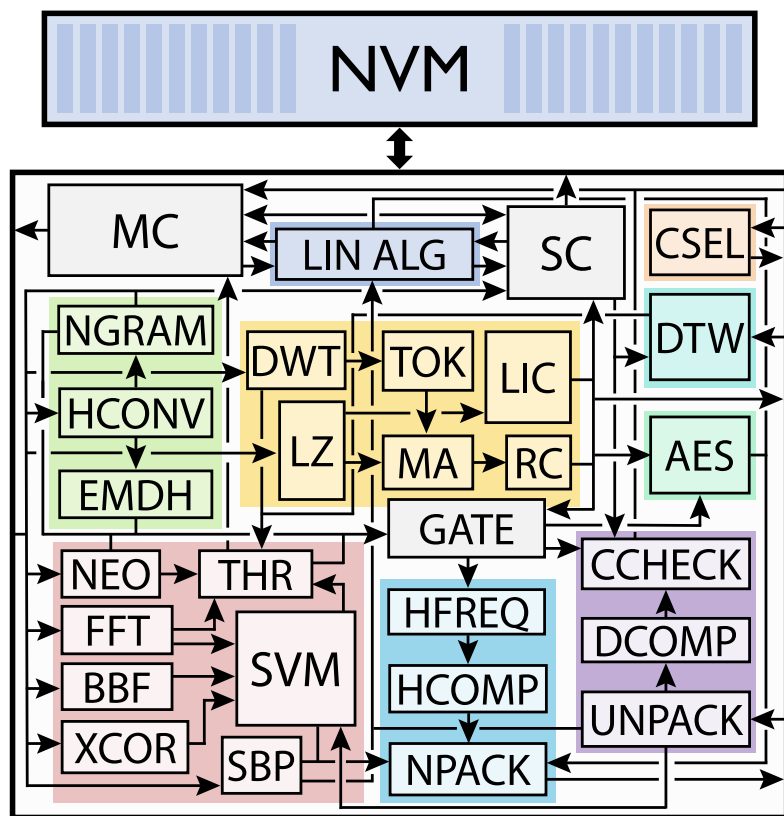


Existing Systems

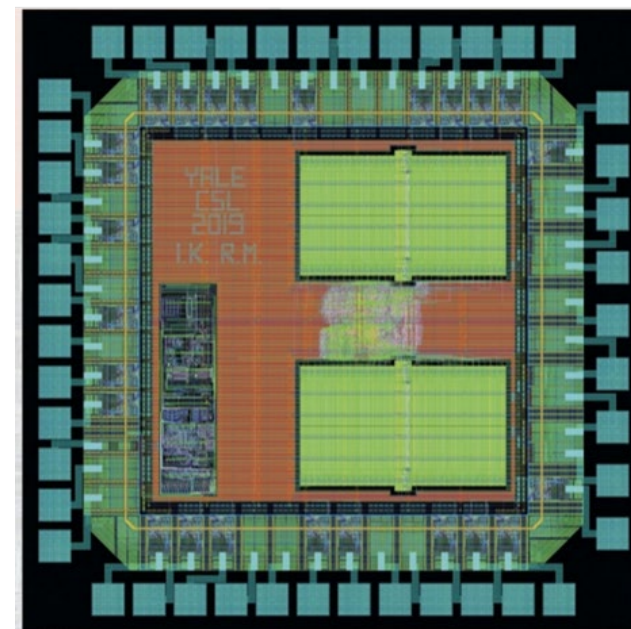
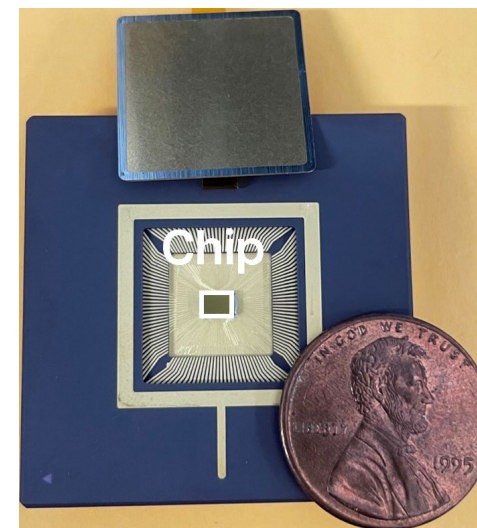


SCALO
 46 Mbps
 128 GB NVM
 Many Accelerators

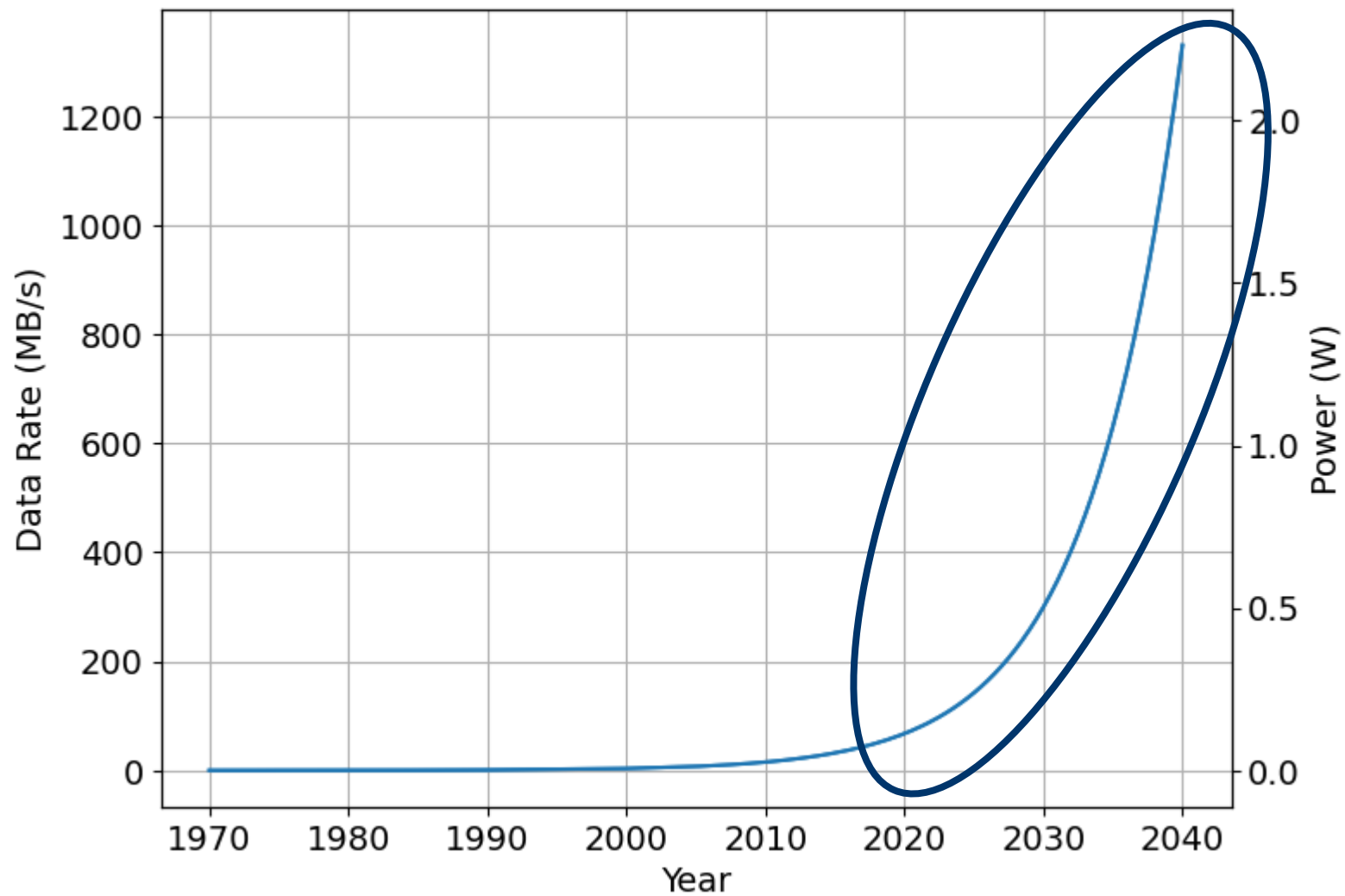
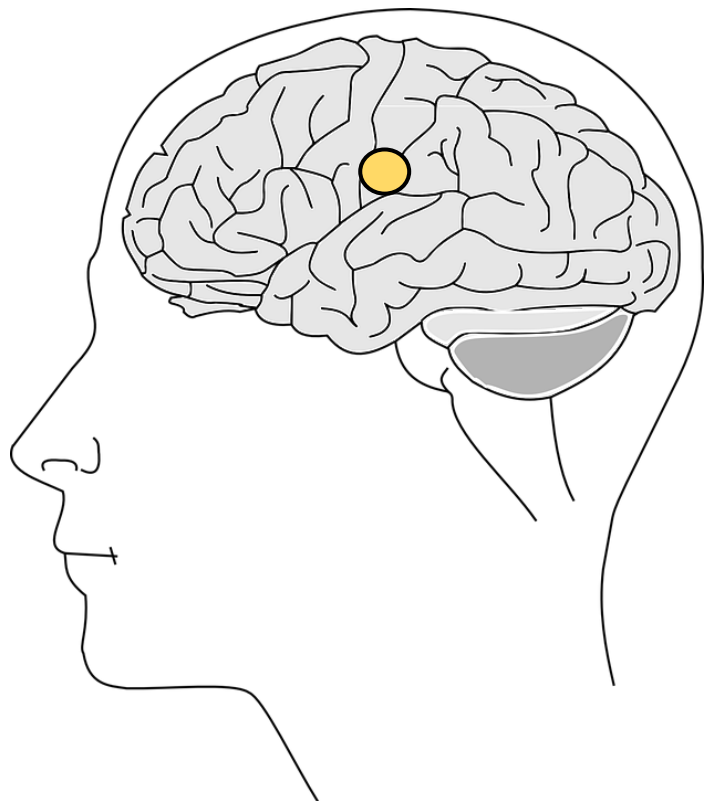
Existing Systems



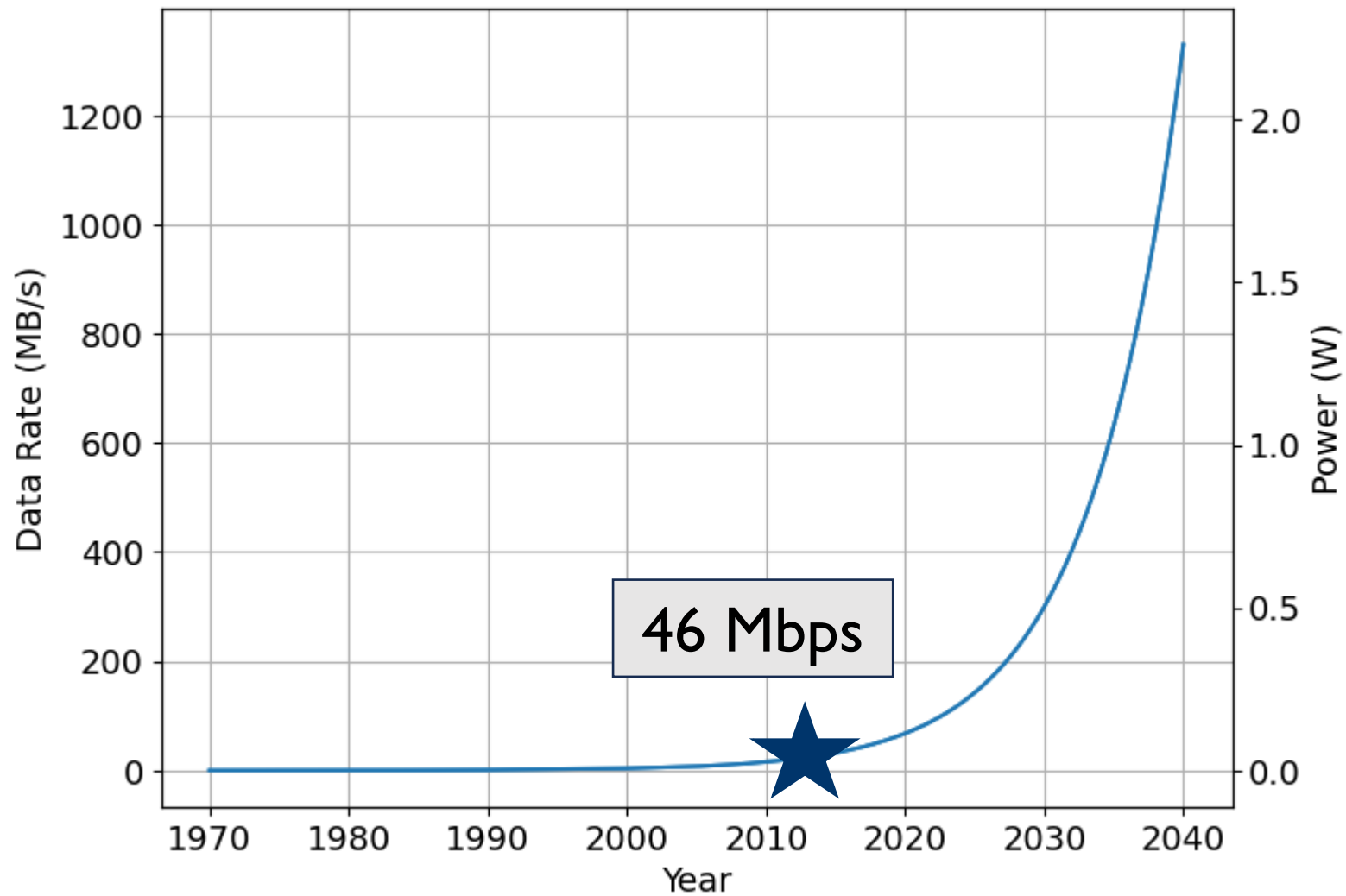
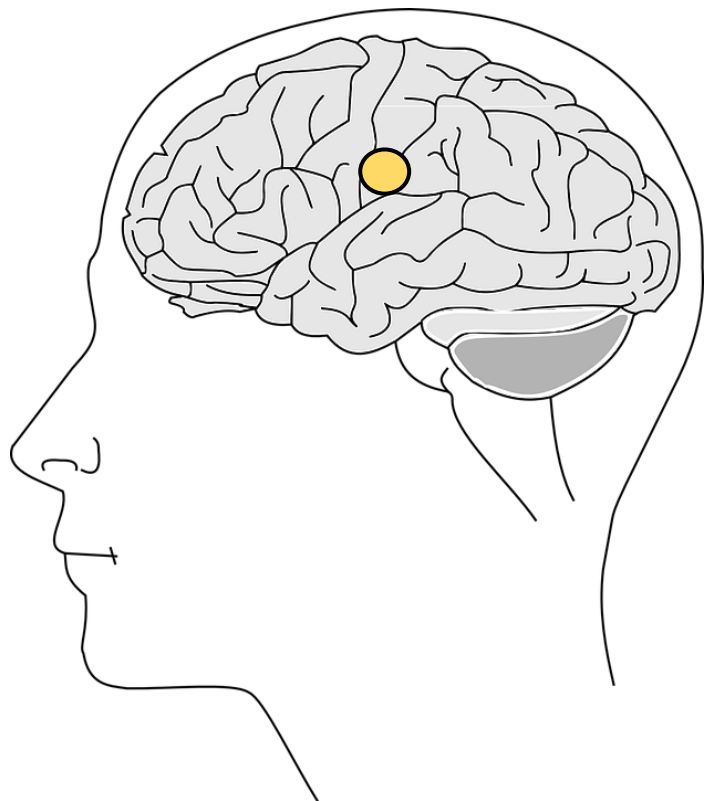
SCALO
 46 Mbps
 128 GB NVM
 Many Accelerators



Long-Term Vision



Fixed Data Rate



Cannot Rely on SRAM

Spectral Analysis

Fast Fourier Transform (FFT)

Discrete Wavelet Transform (DWT)

Butterworth Bandpass Filter (BBF)

Similarity Measures

Dynamic Time Warping (DTW)

Cross Correlation (XCOR)

Cannot Rely on SRAM

Spectral Analysis

Fast Fourier Transform (FFT)

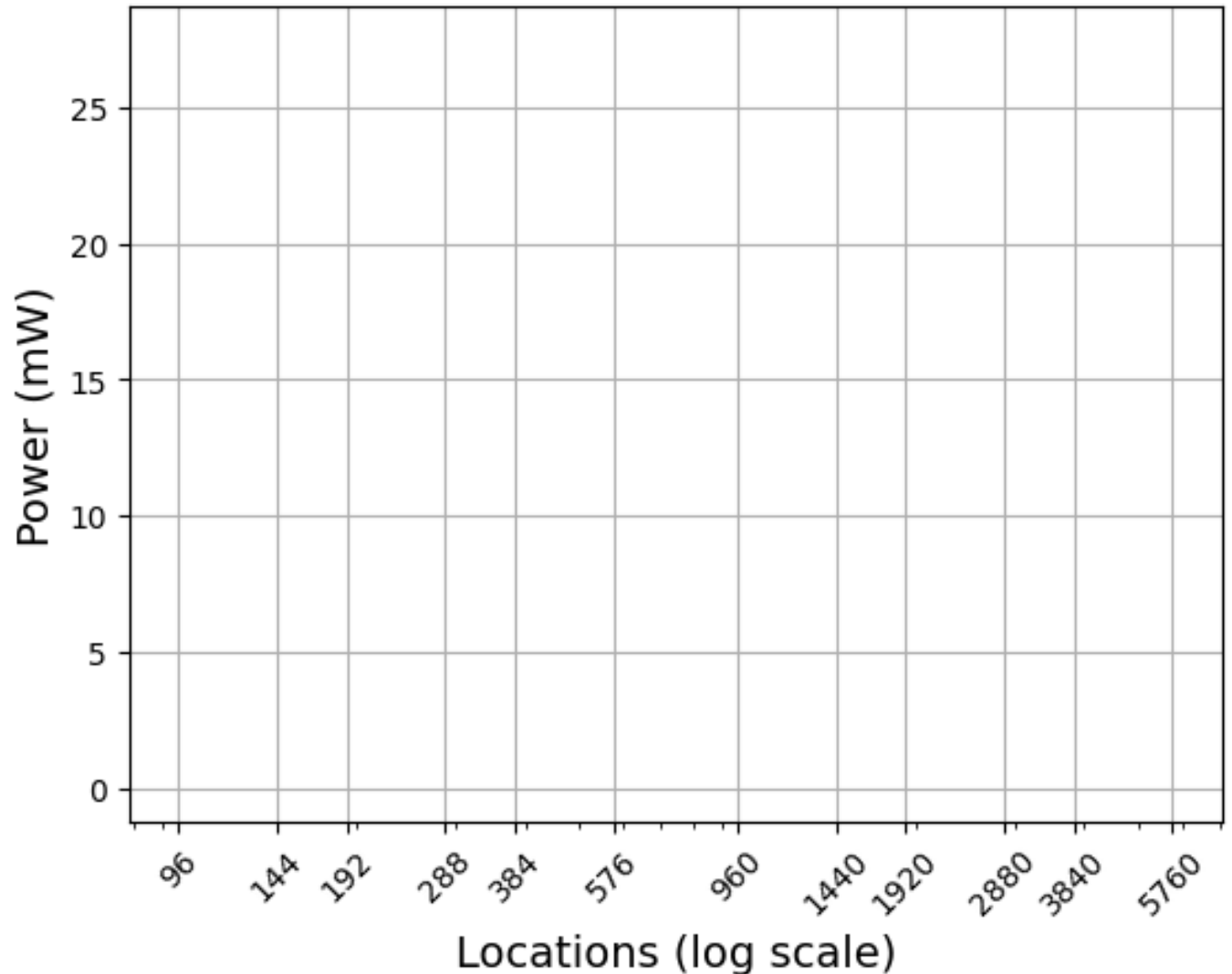
Discrete Wavelet Transform (DWT)

Butterworth Bandpass Filter (BBF)

Similarity Measures

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Cross Correlation (XCOR)



Cannot Rely on SRAM

Spectral Analysis

Fast Fourier Transform (FFT)

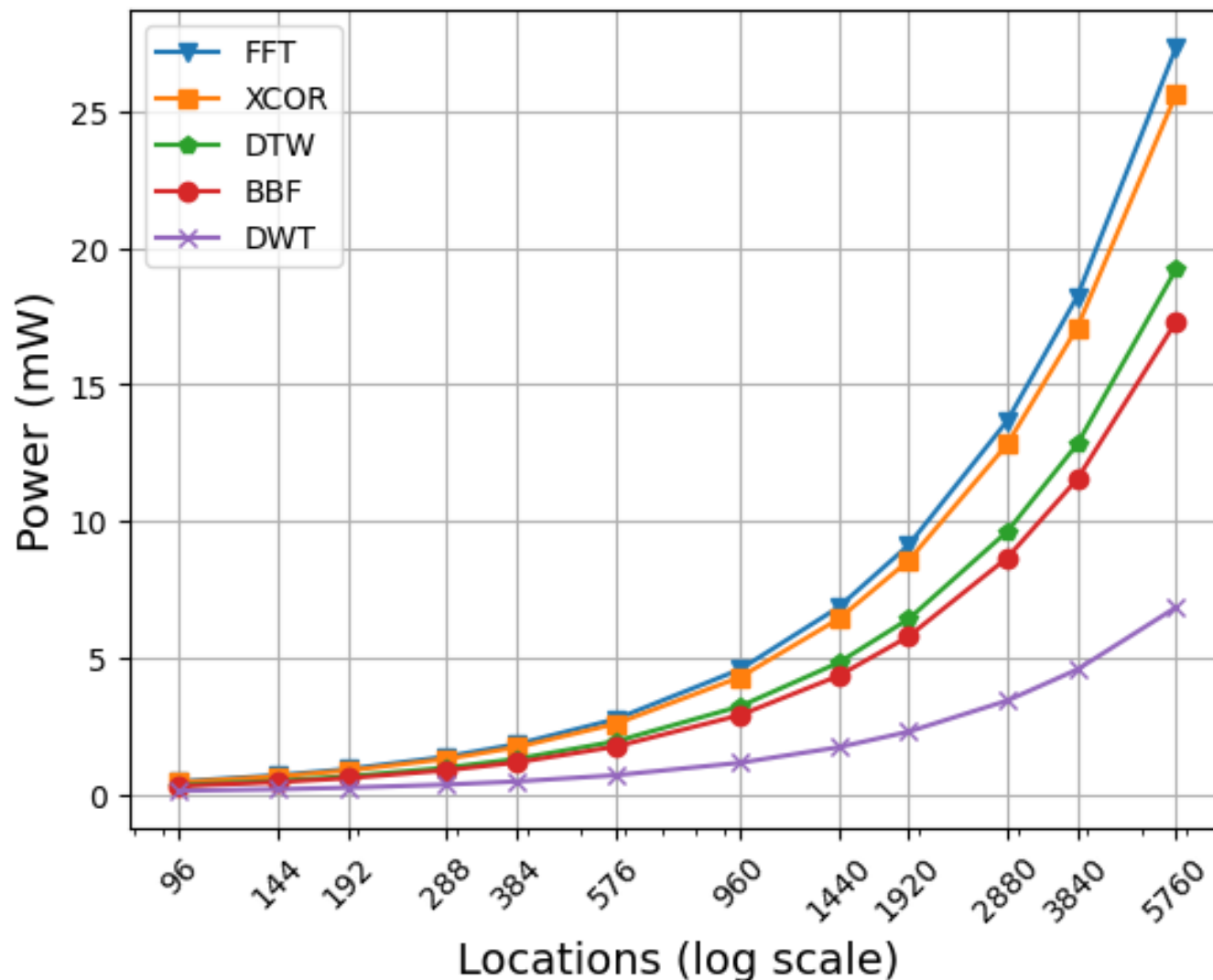
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Butterworth Bandpass Filter (BBF)

Similarity Measures

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Cannot Rely on SRAM

Spectral Analysis

Fast Fourier Transform (FFT)

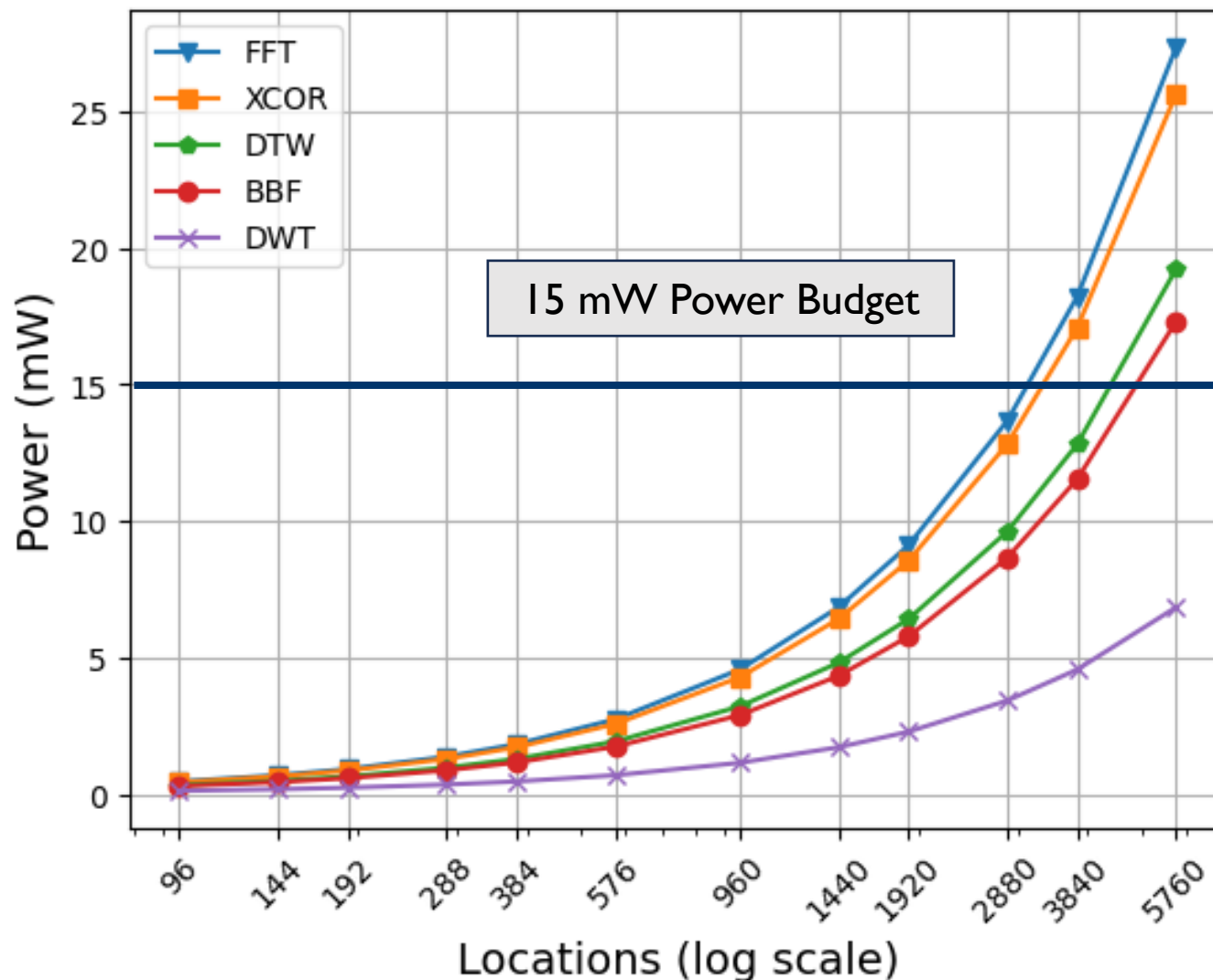
Discrete Wavelet Transform (DWT)

Butterworth Bandpass Filter (BBF)

Similarity Measures

Dynamic Time Warping (DTW)

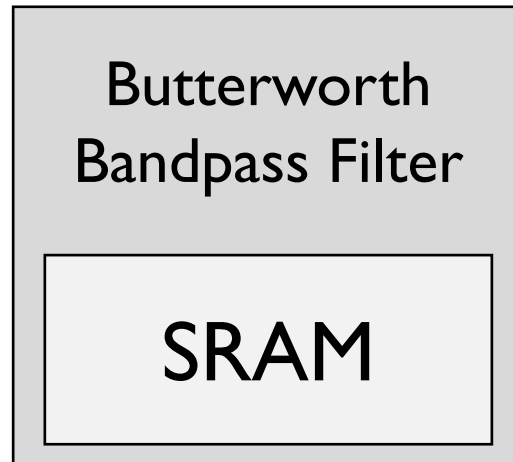
Cross Correlation (XCOR)



We Propose Swapping

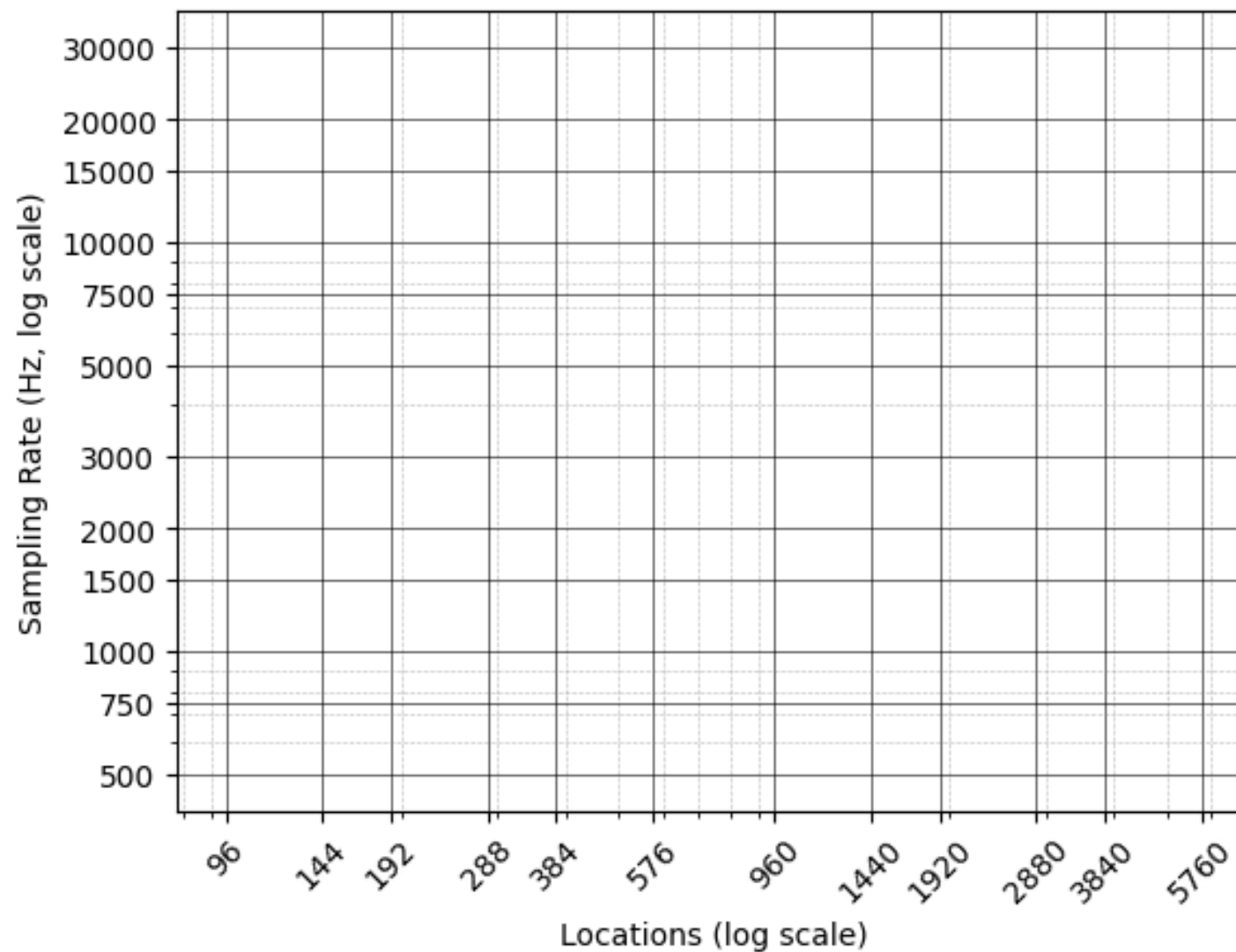
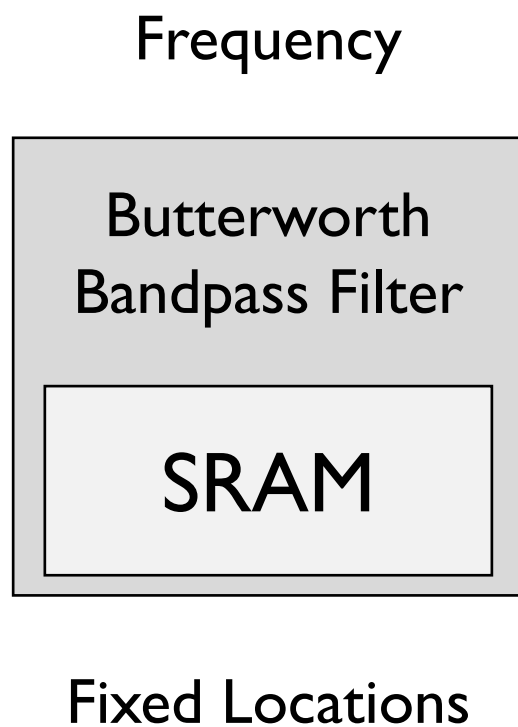
BBF Example

Frequency



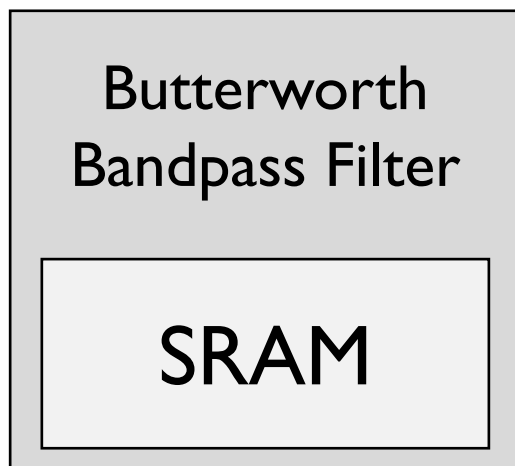
Fixed Locations

BBF Example

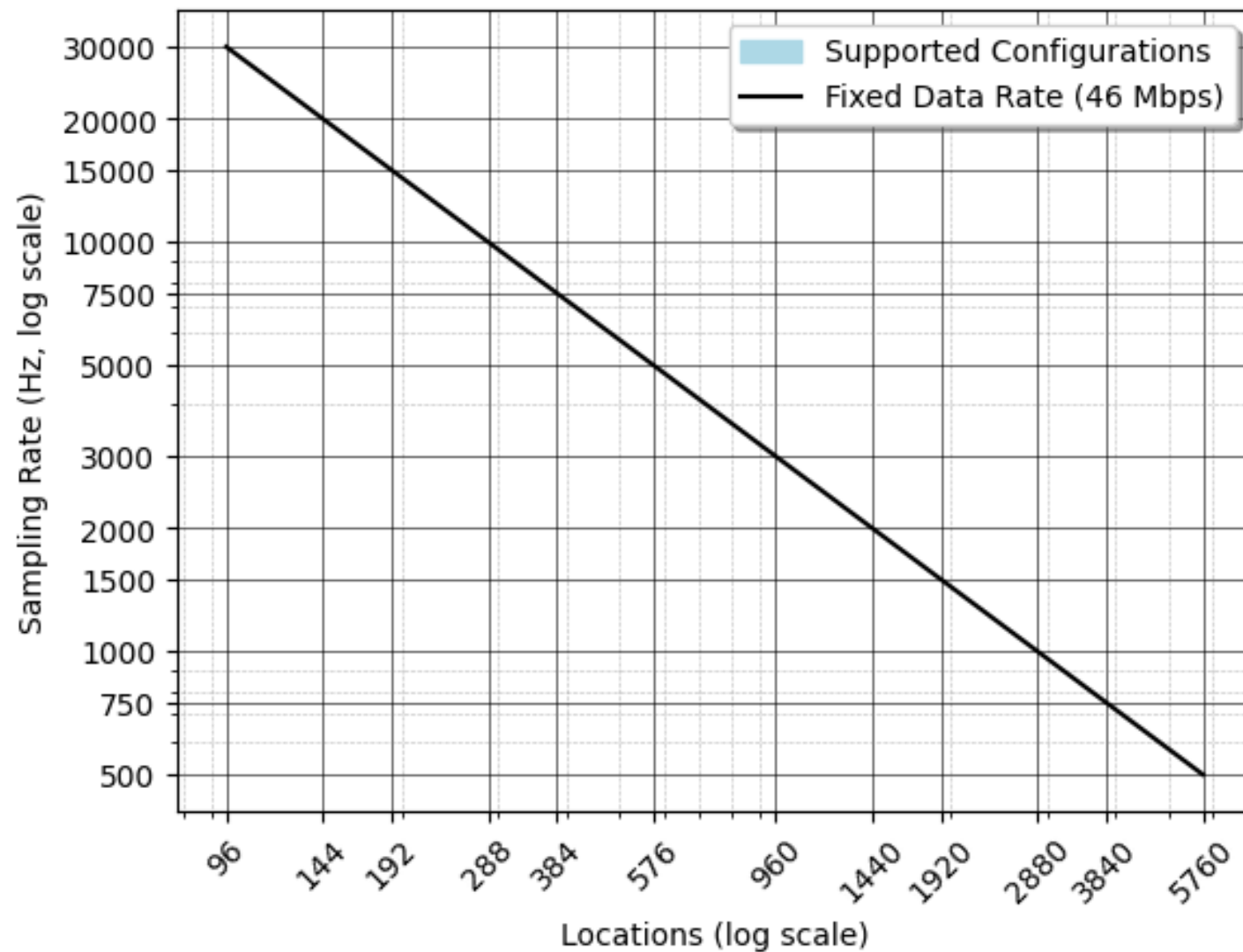


BBF Example

Frequency

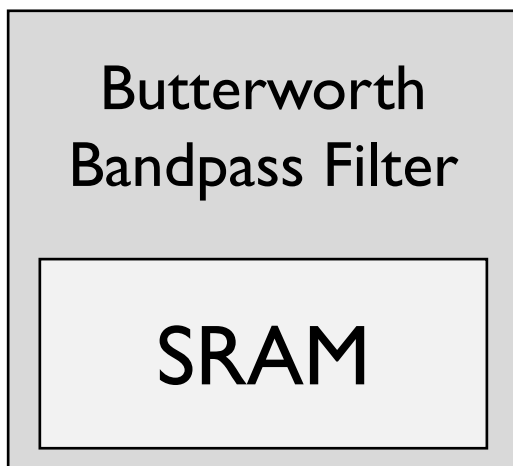


Fixed Locations

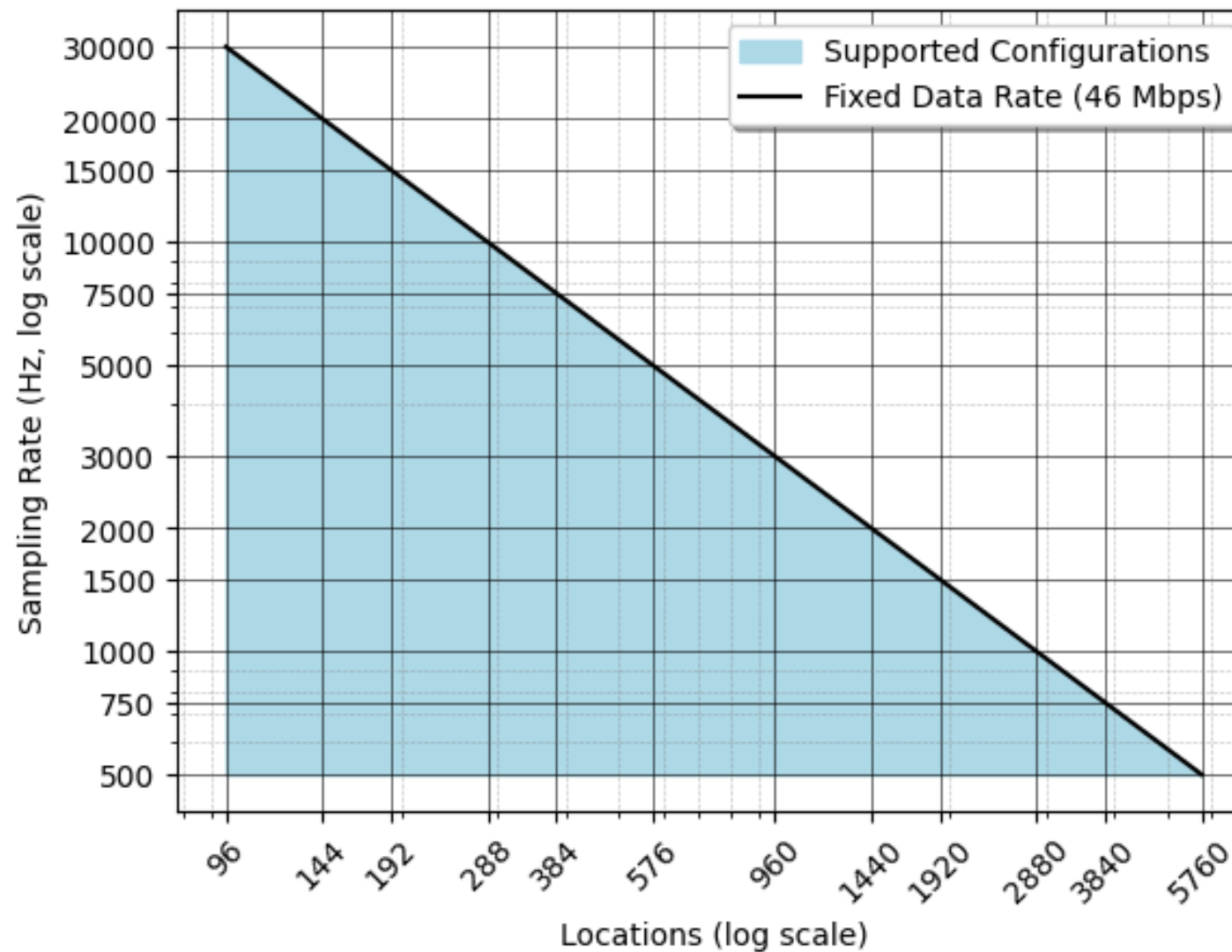


Ideal System

Frequency

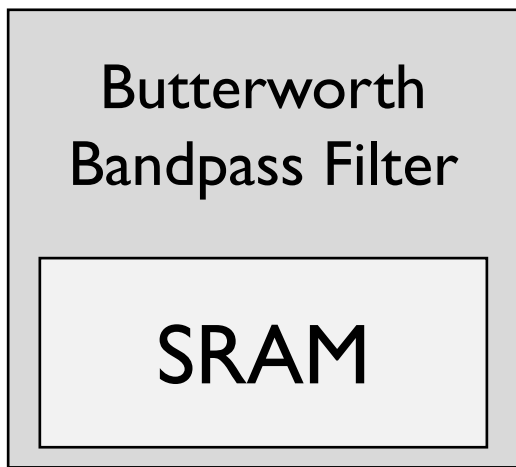


Fixed Locations

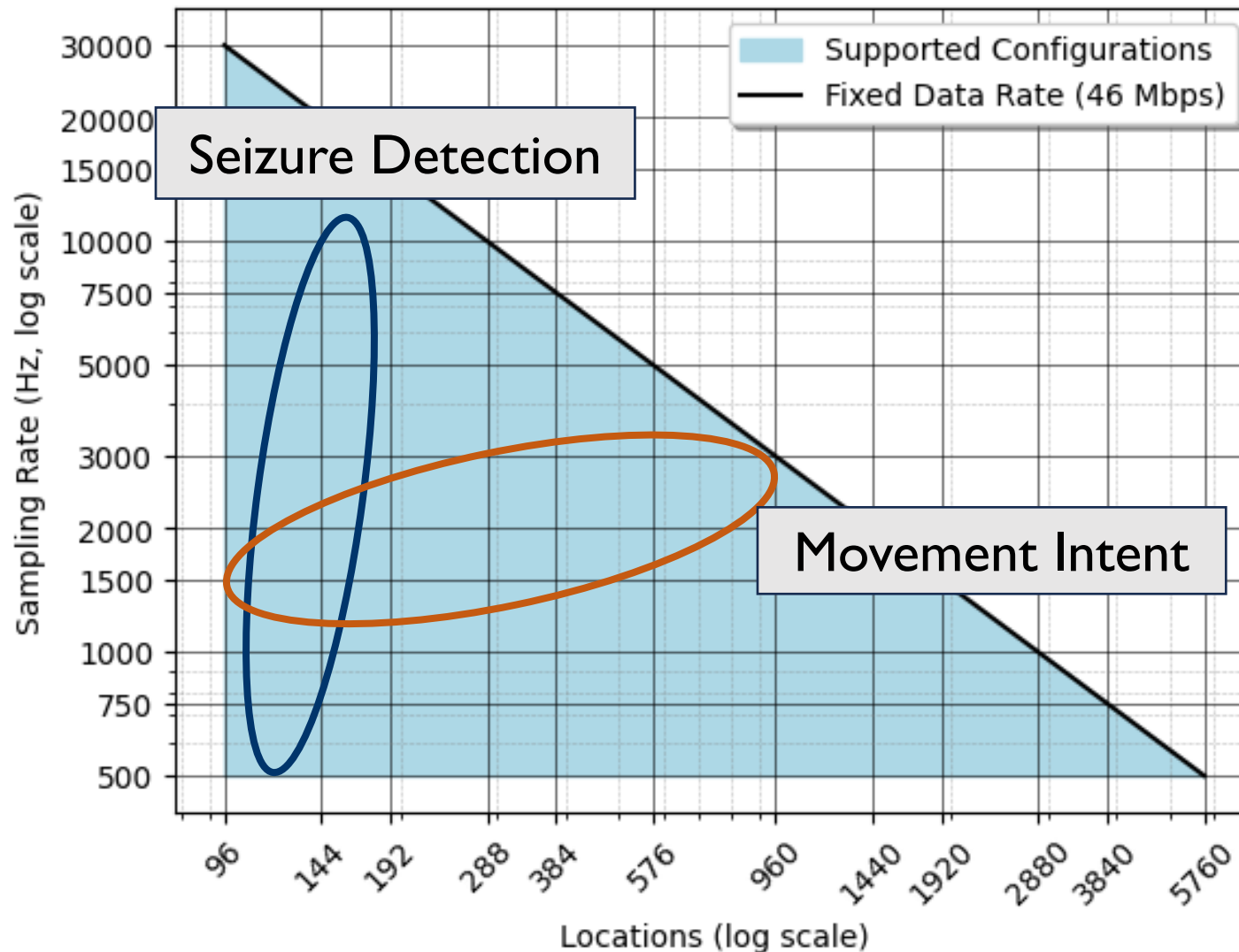


Personalized Treatment

Frequency

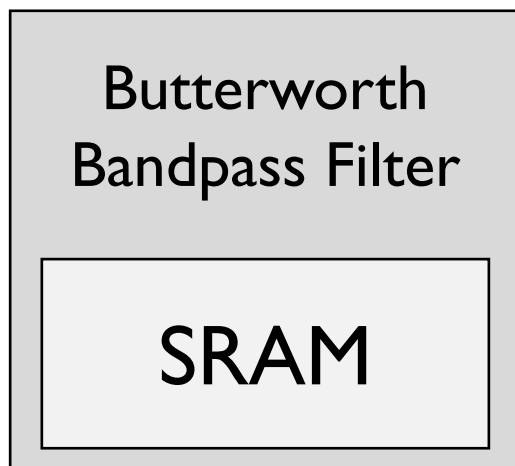


Fixed Locations

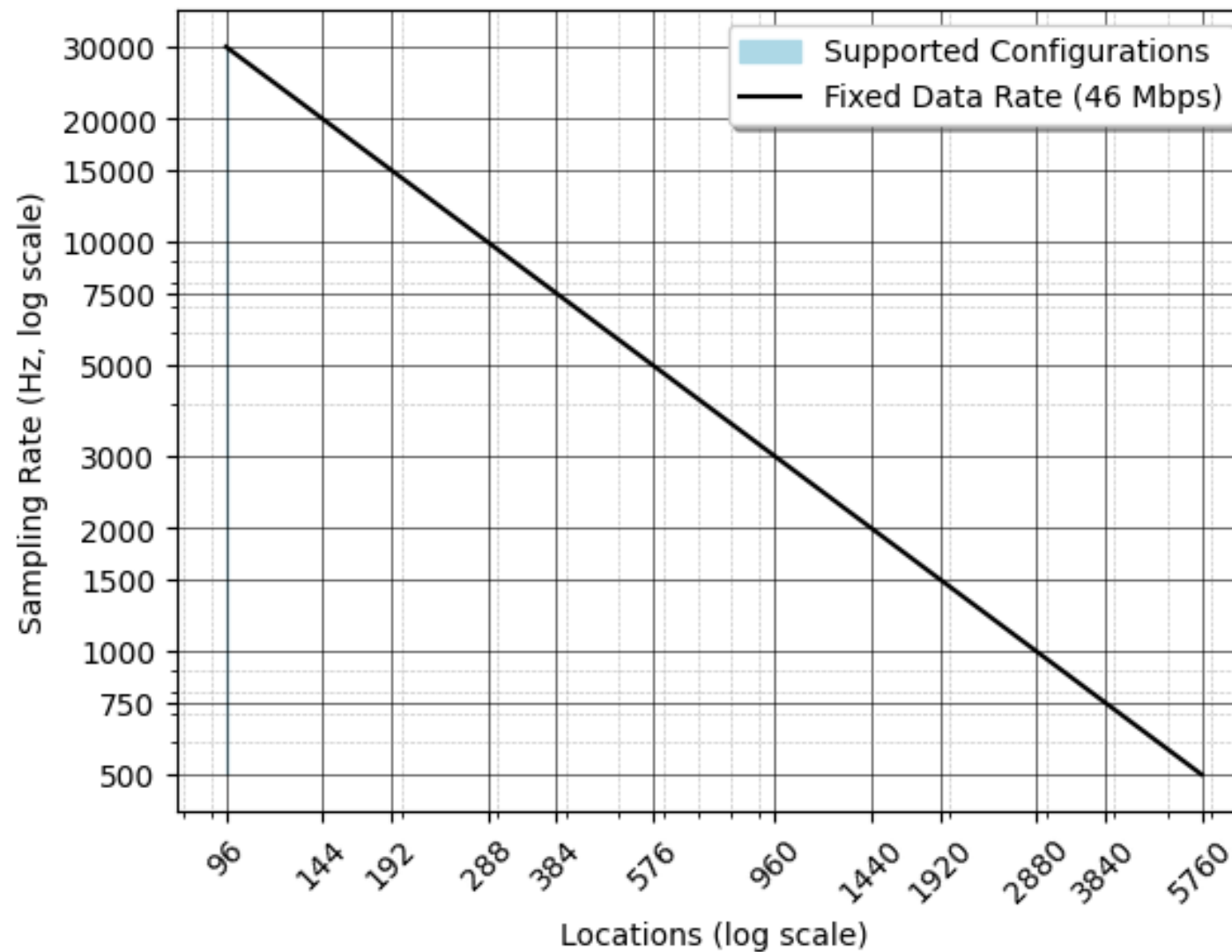


Existing System

Frequency

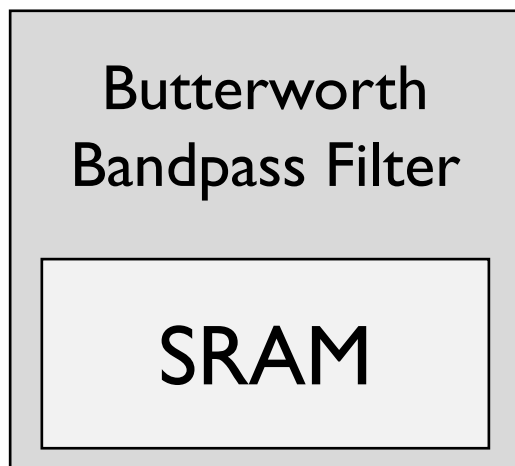


Fixed Locations

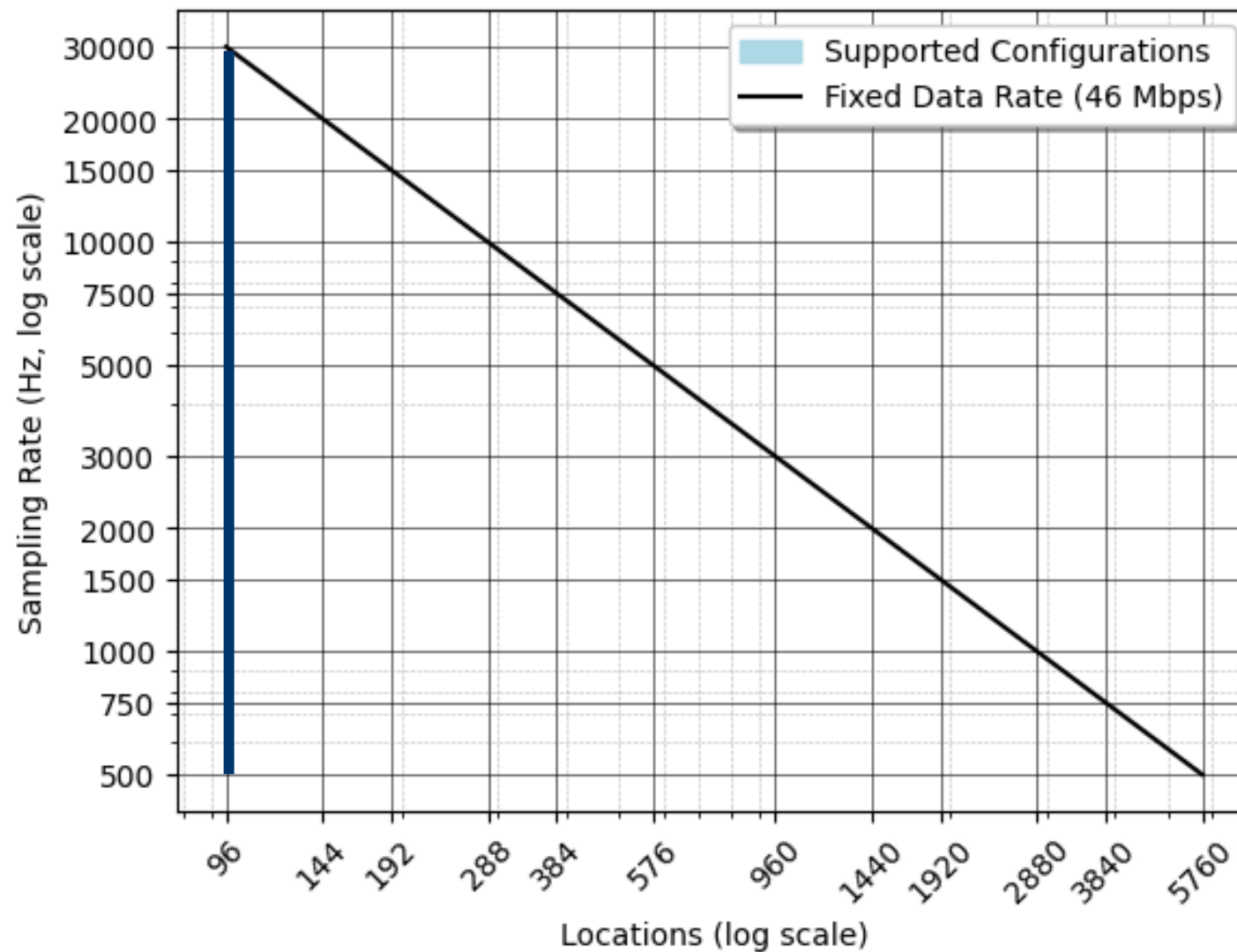


Existing System

Frequency

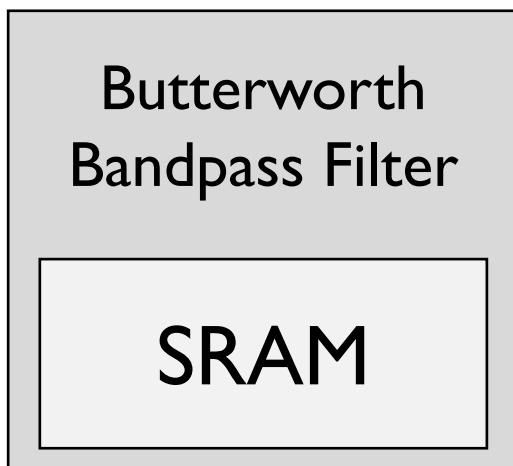


Fixed Locations

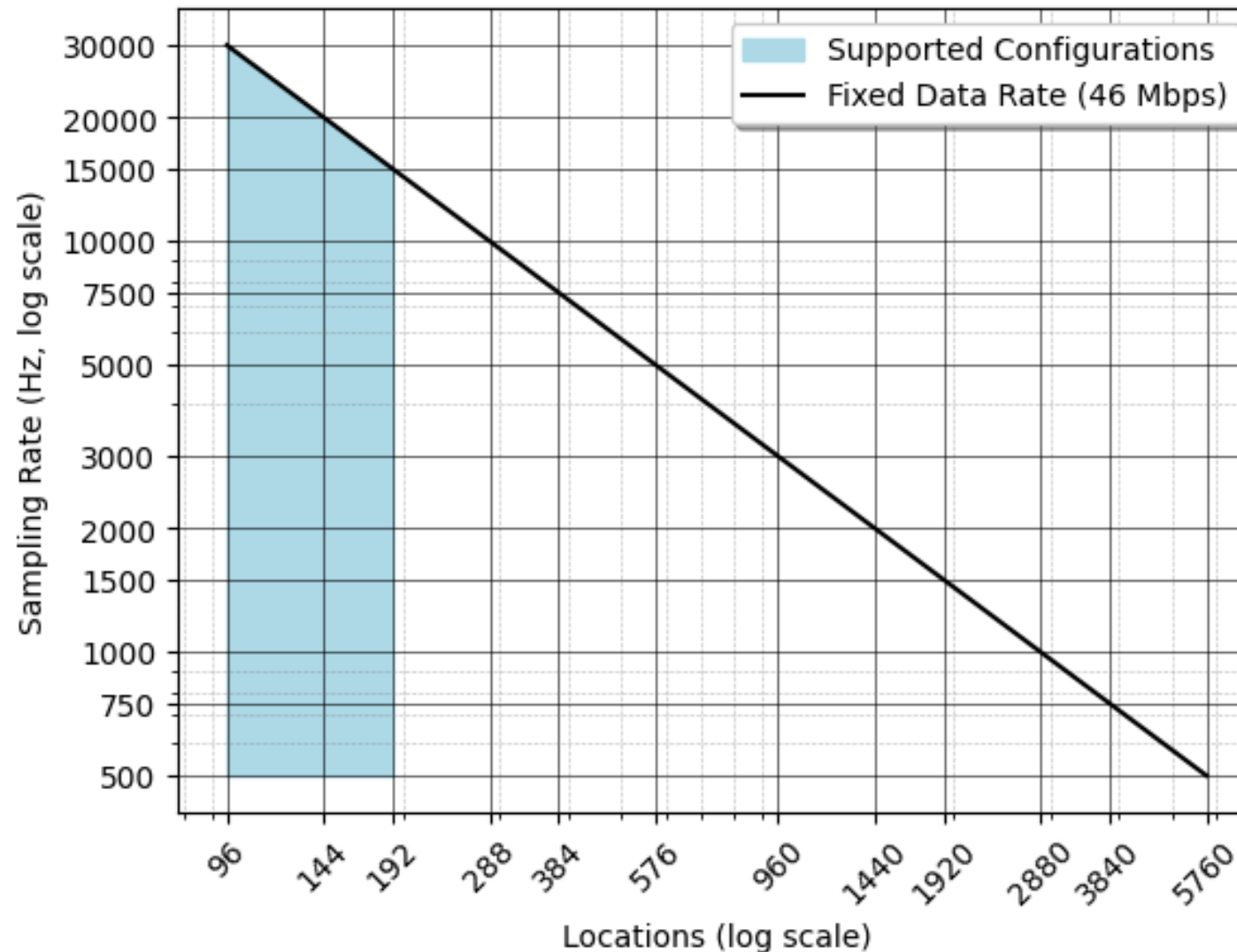


Adding SRAM

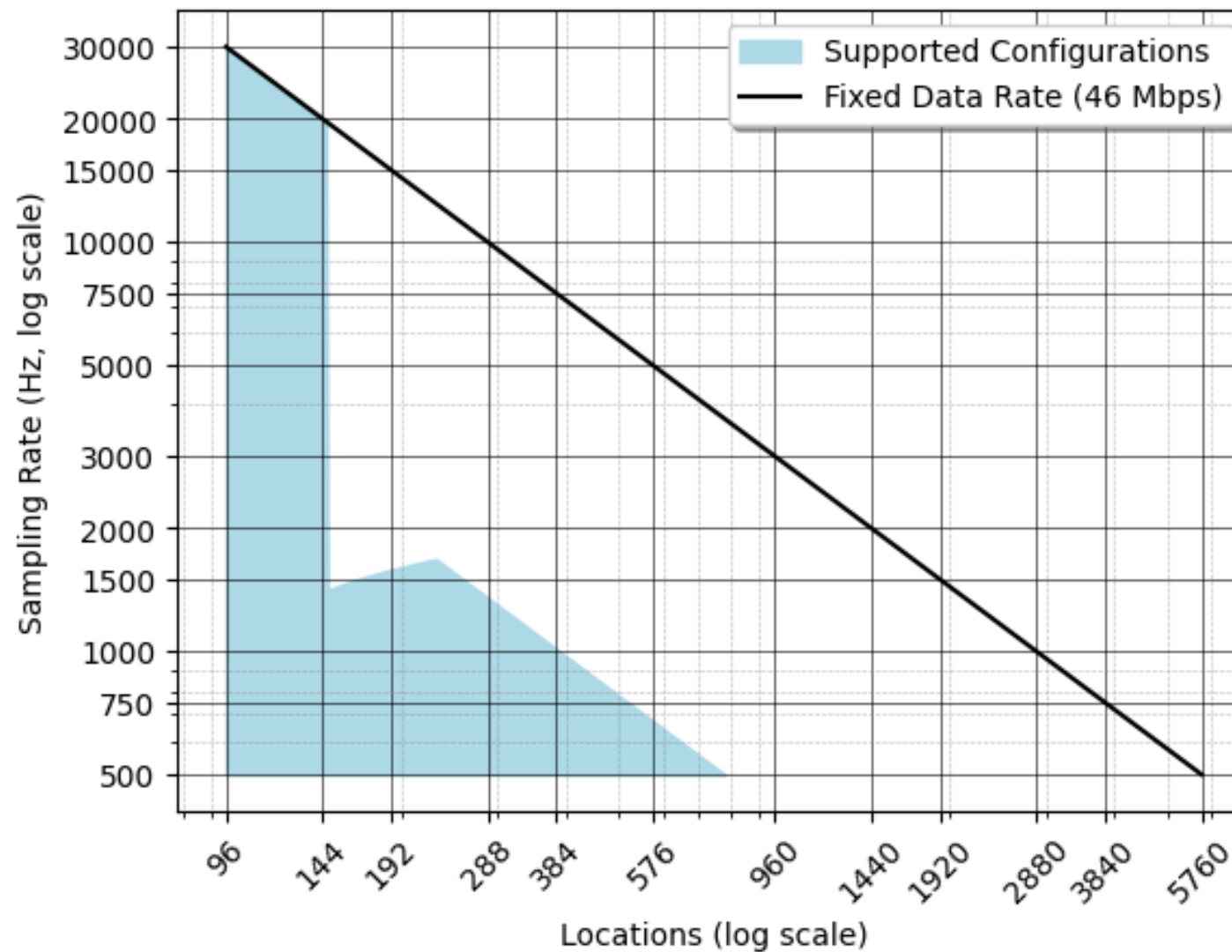
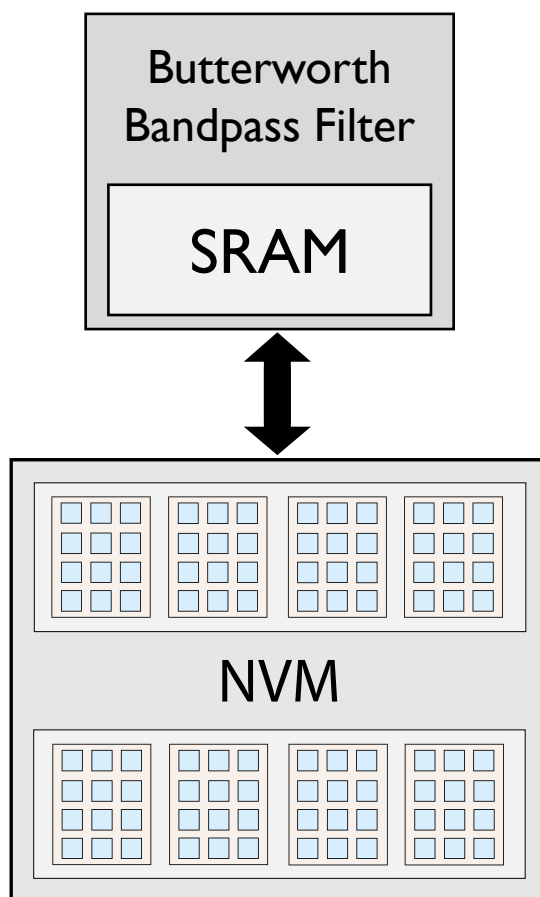
Same Frequency



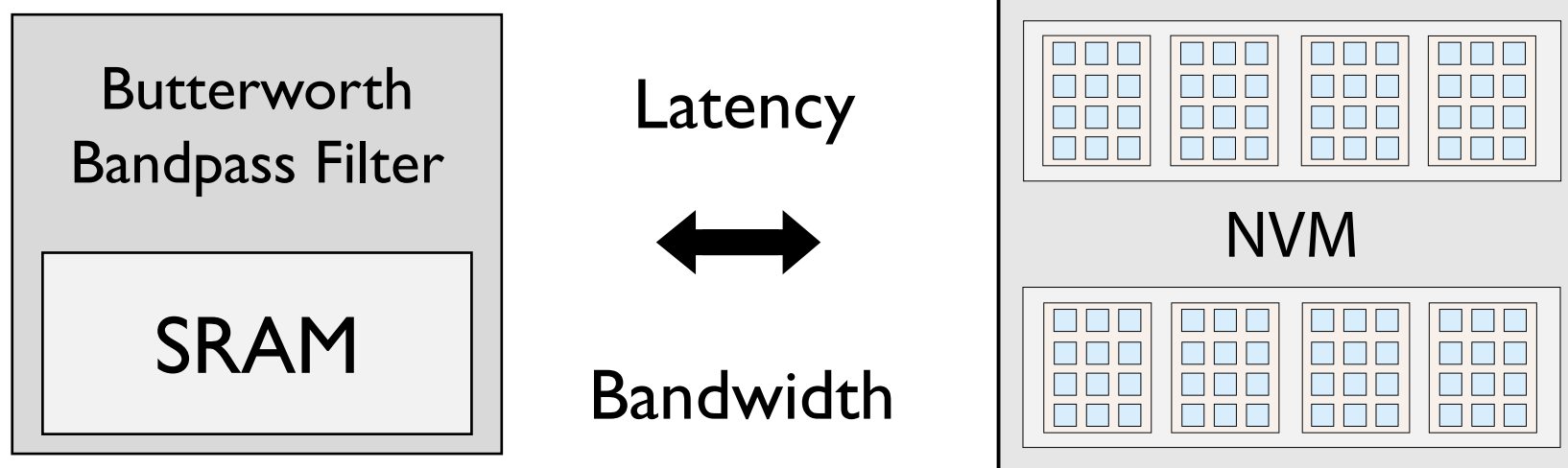
More Locations



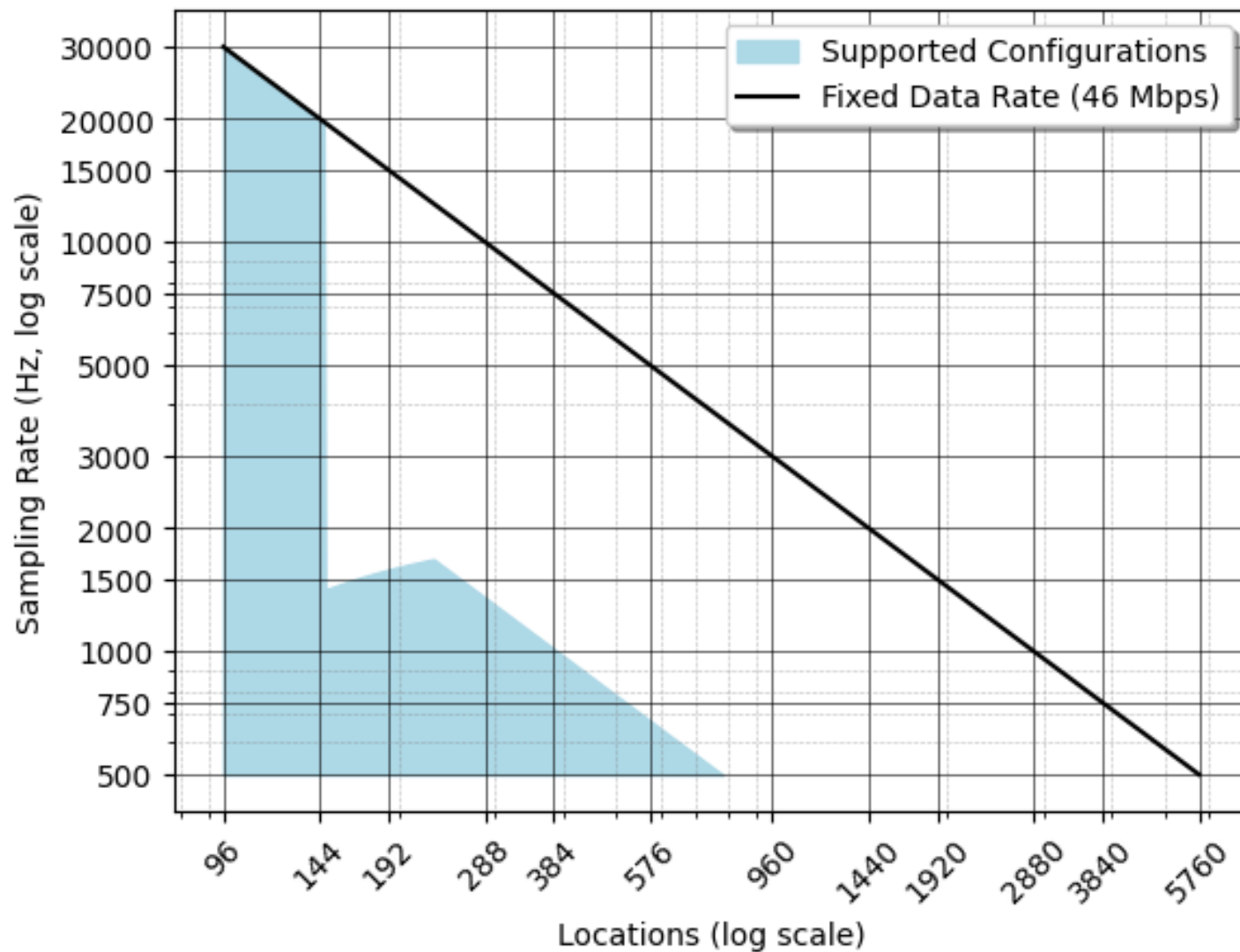
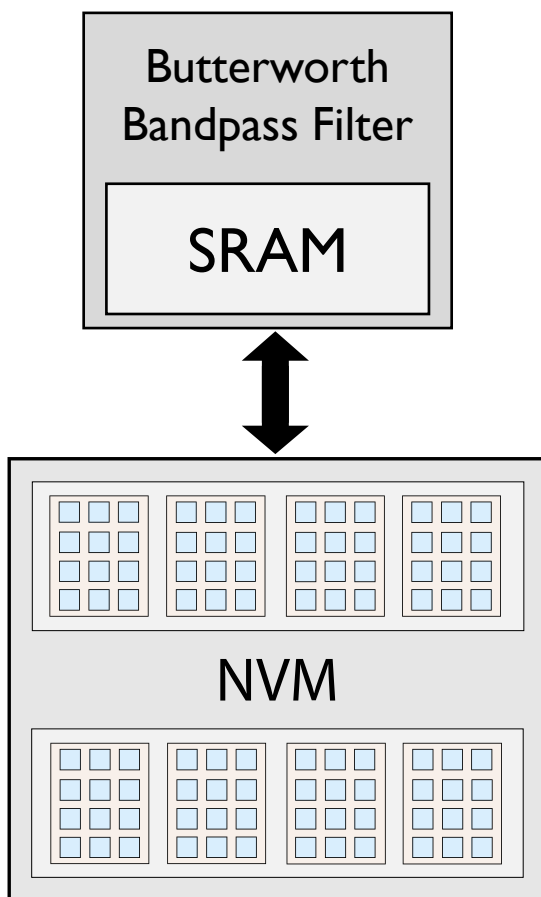
Promise of Swapping



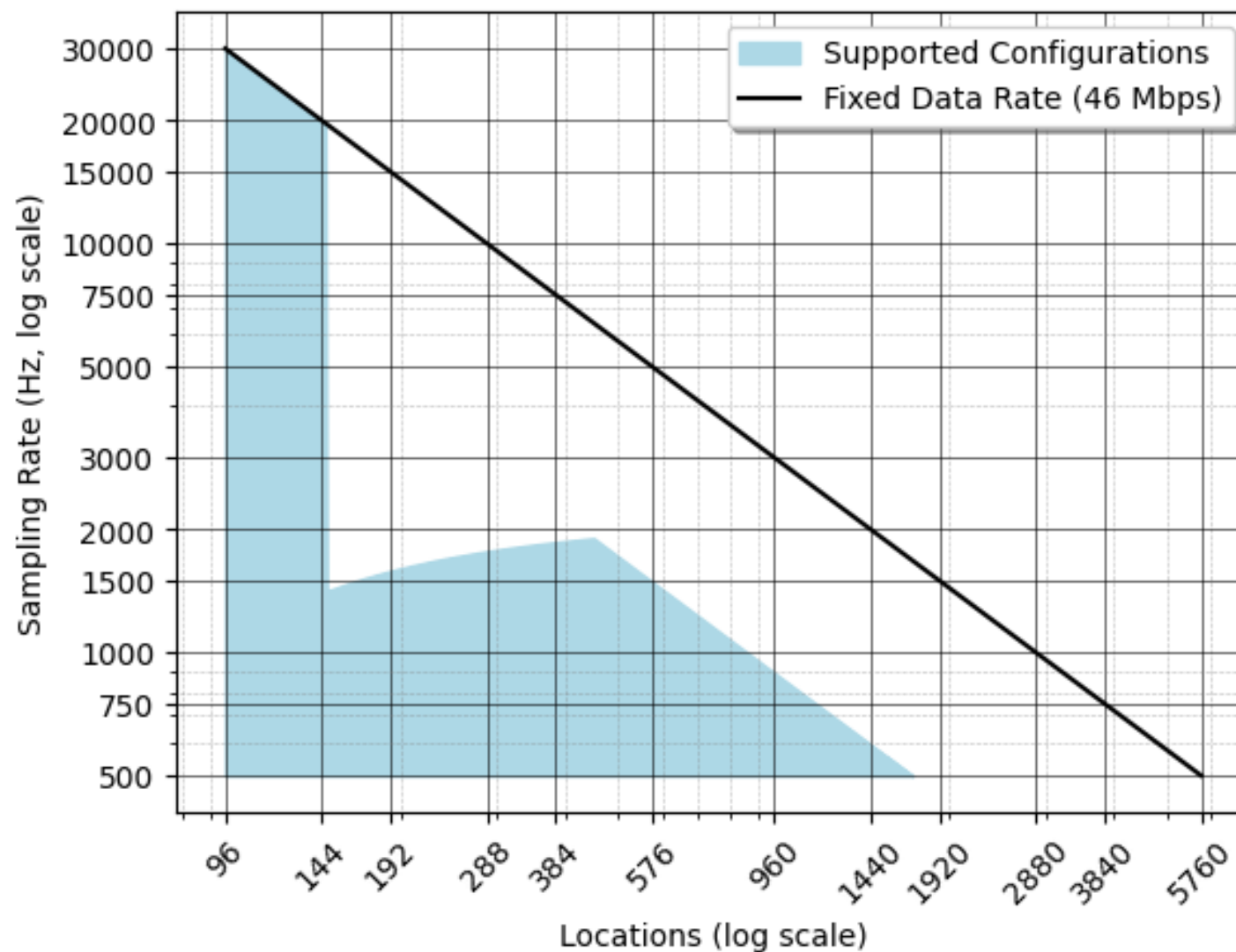
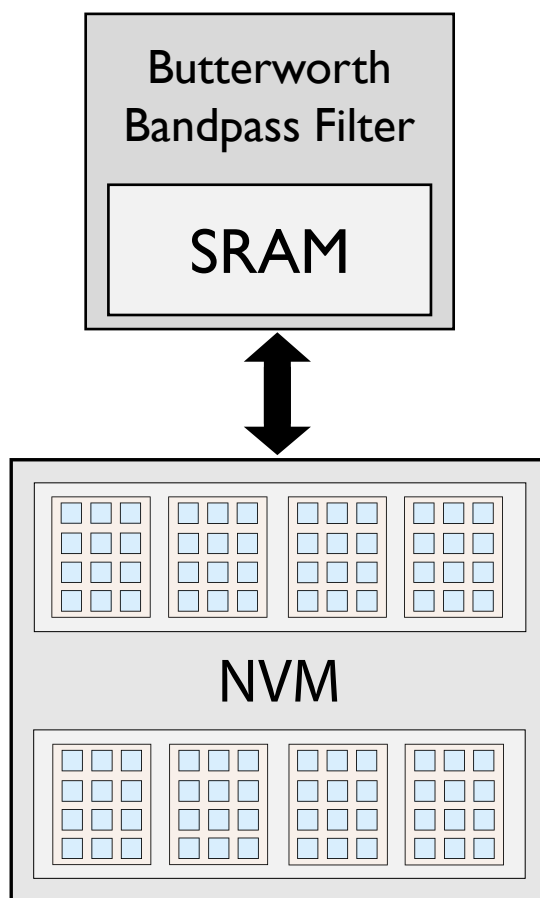
Constraints for Swapping



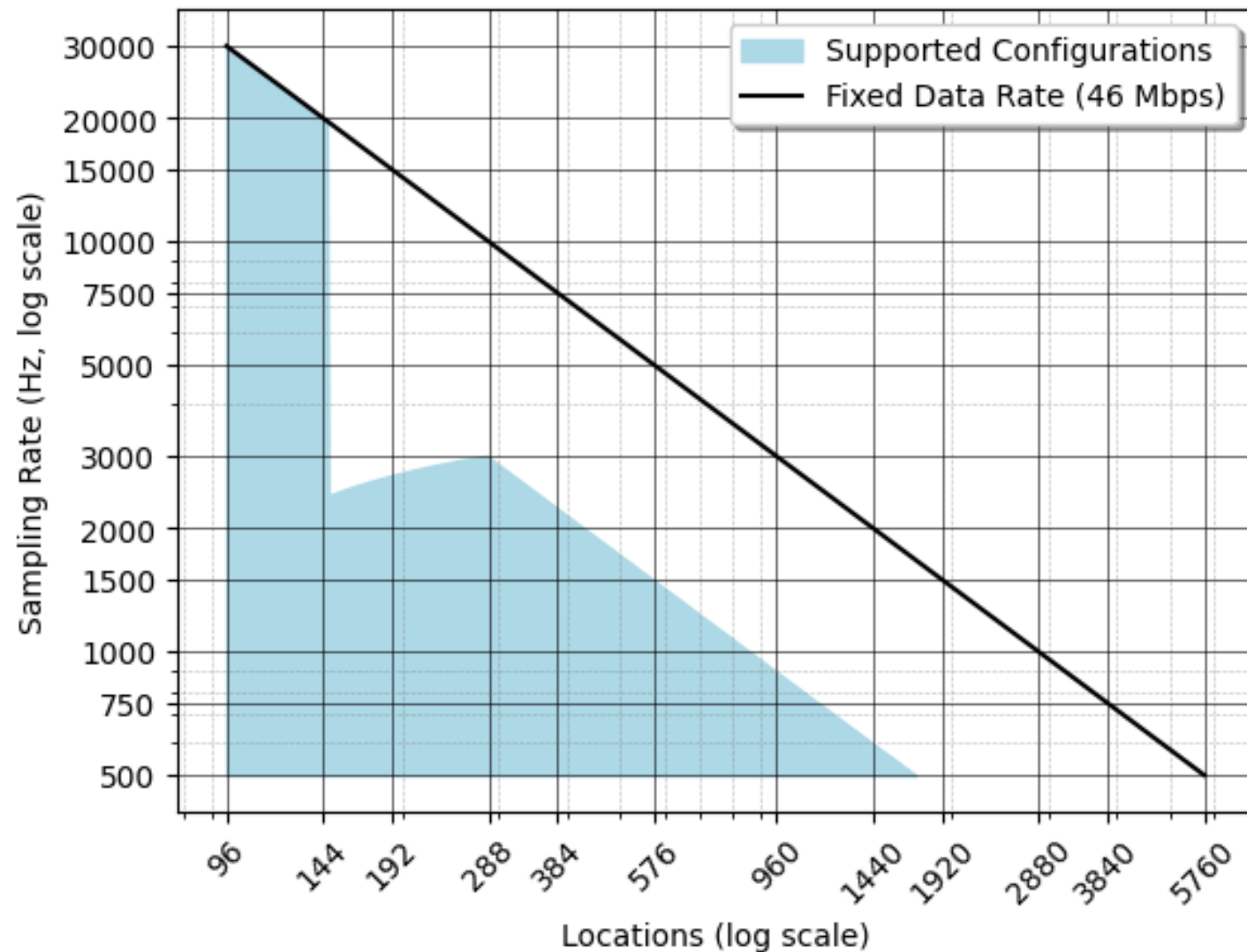
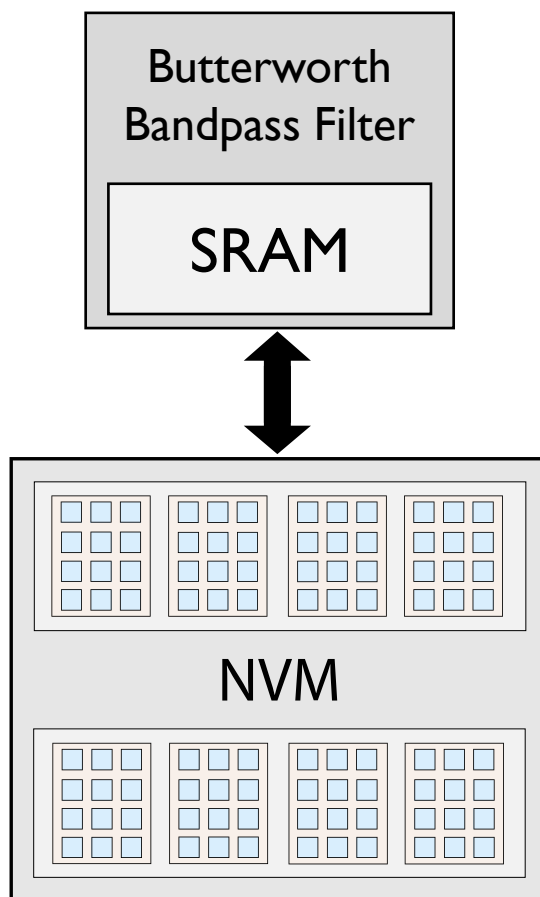
Shaping Coverage



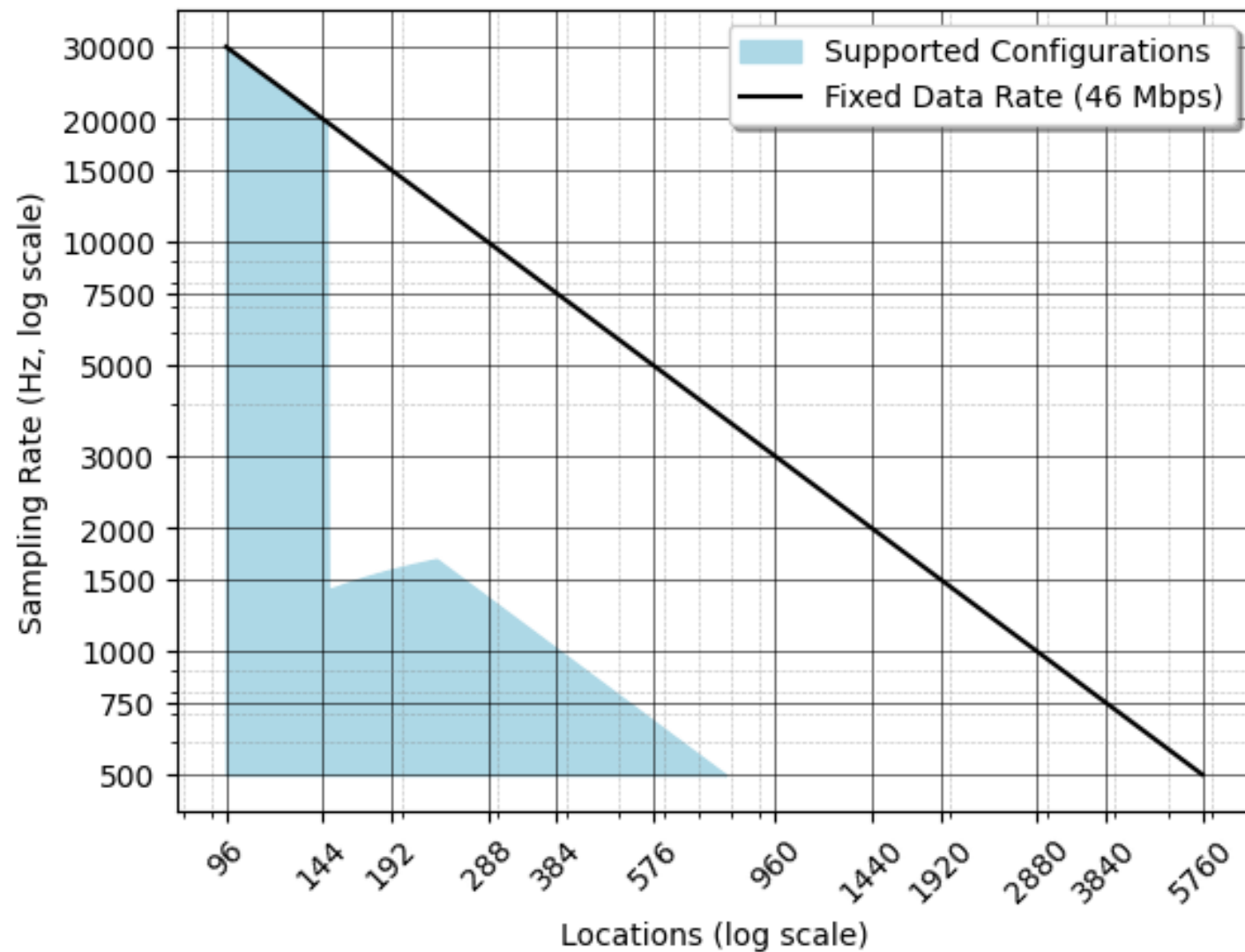
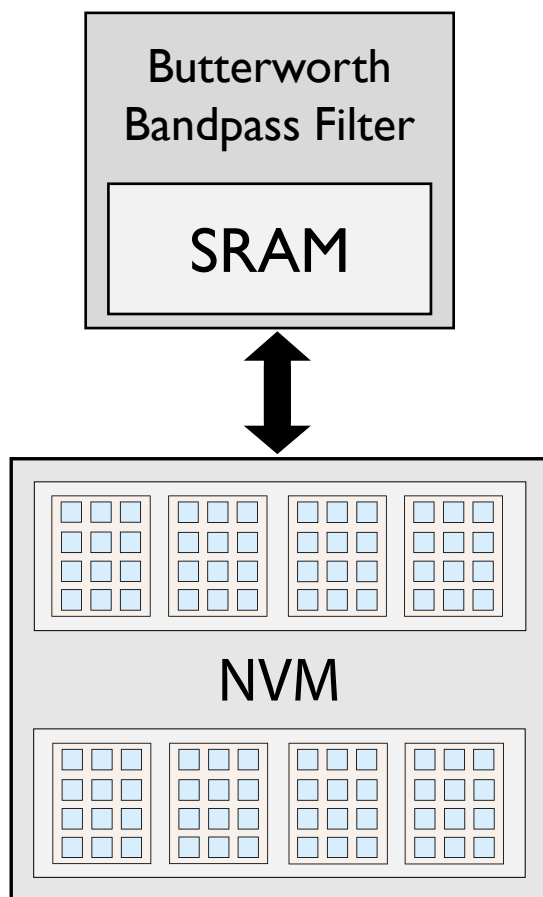
Shaping Coverage (Bandwidth)

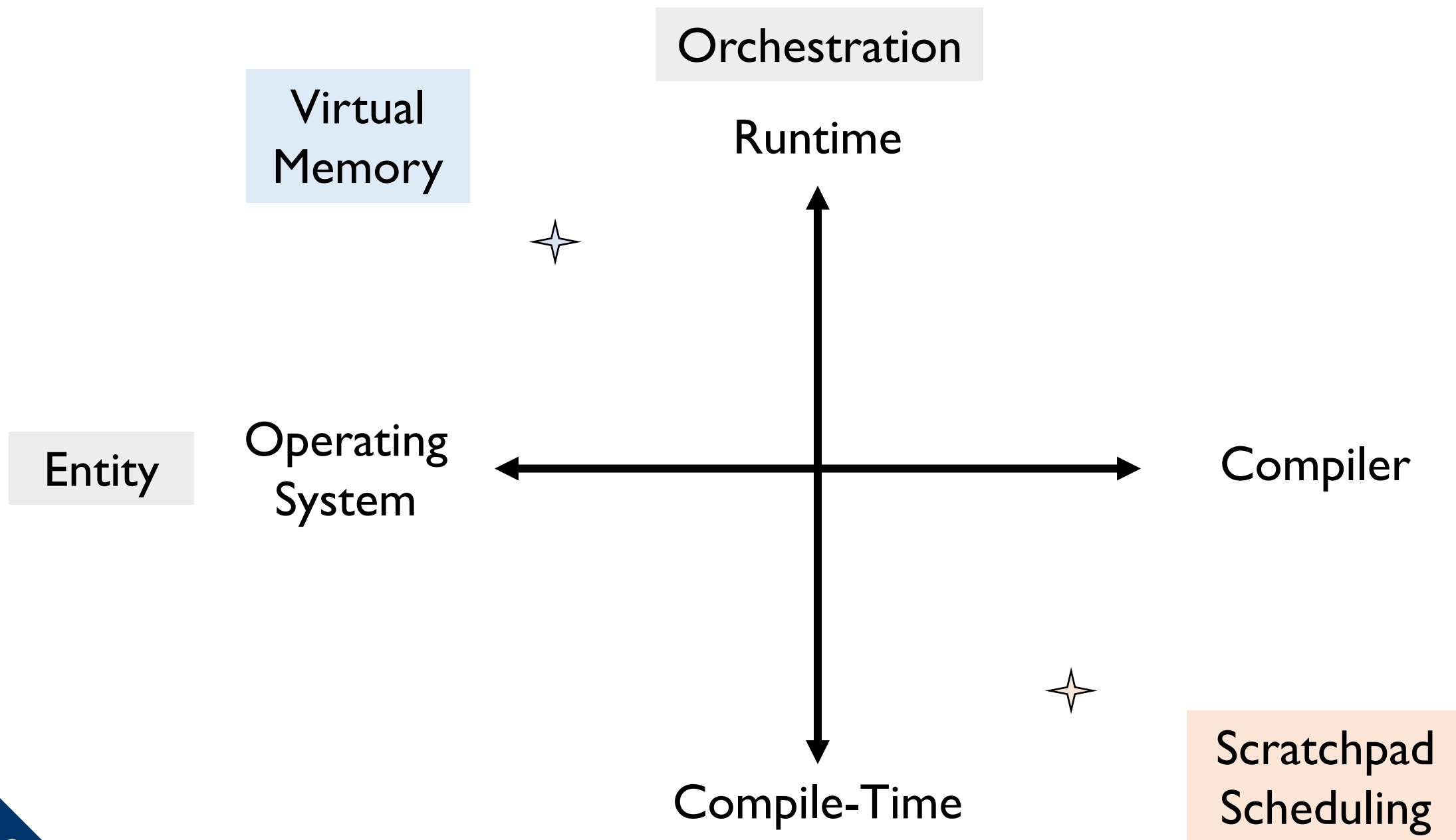


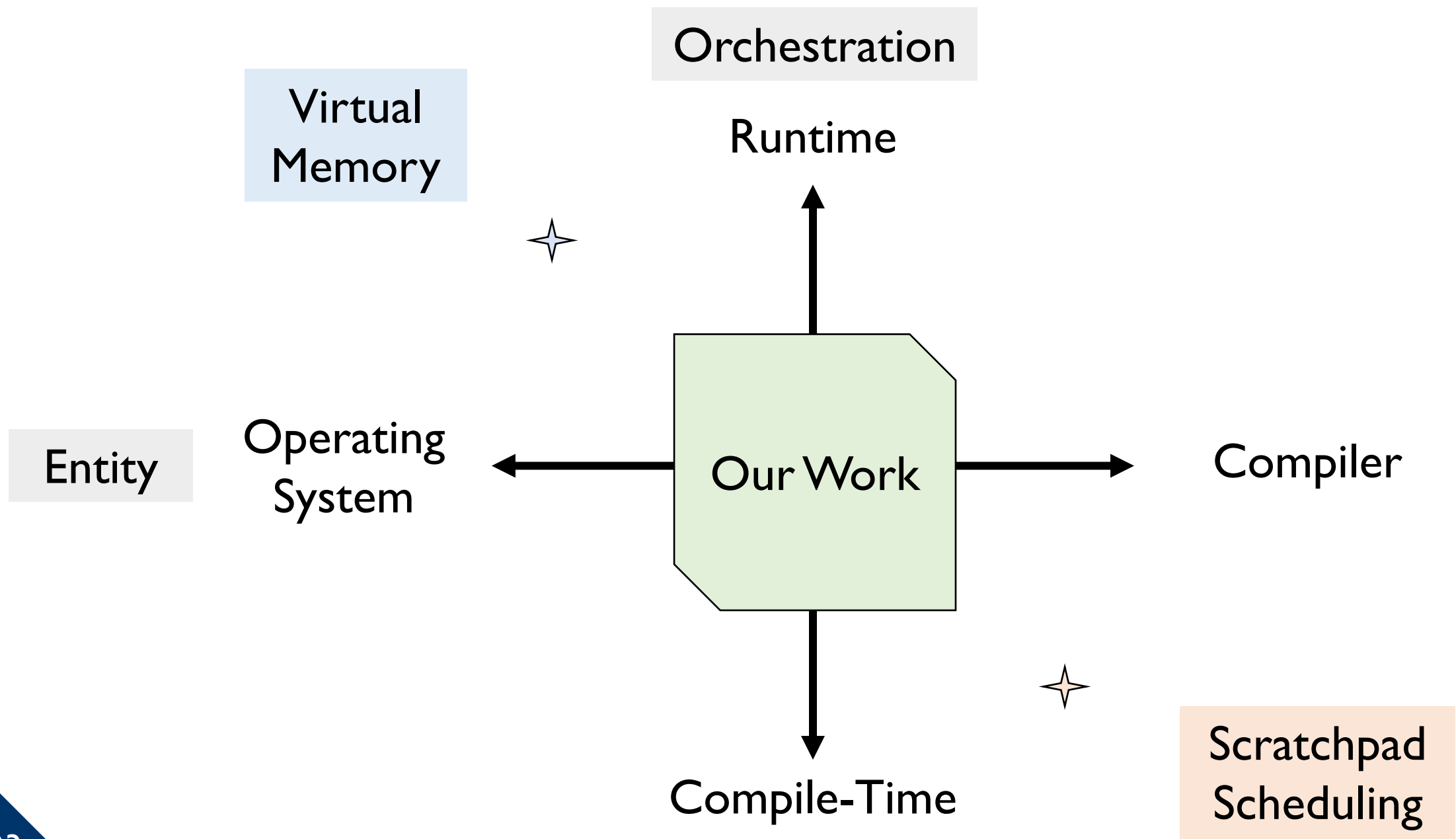
Shaping Coverage (Latency)



Promise of Swapping







Takeaways

Takeaways

- NVMs are the future of neural interfaces

Takeaways

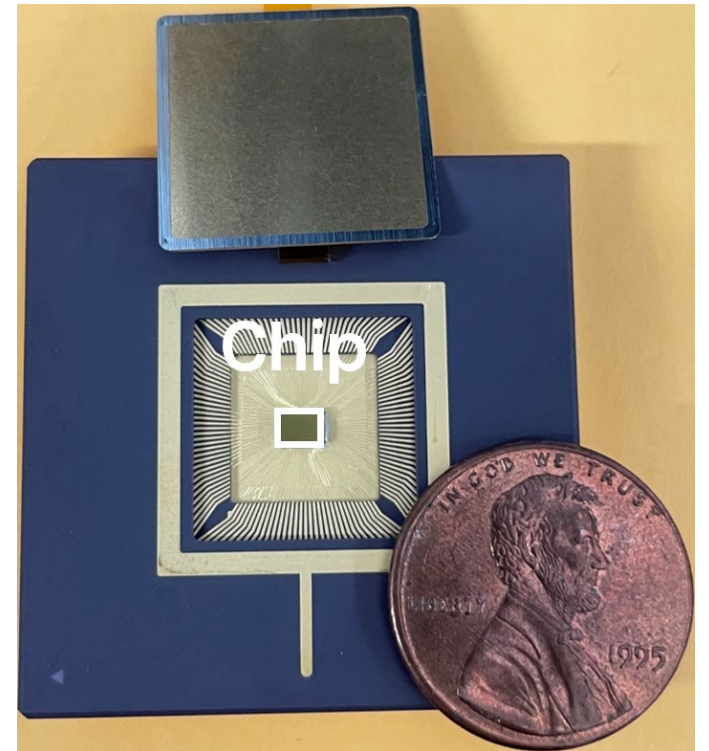
- NVMs are the future of neural interfaces
- We propose swapping as a power optimization

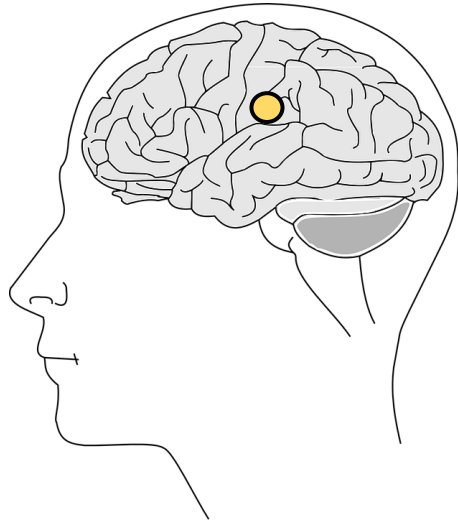
Takeaways

- NVMs are the future of neural interfaces
- We propose swapping as a power optimization
- Exploring both algorithms and devices

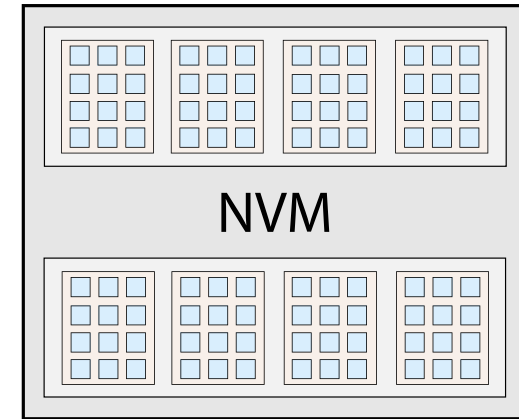
Takeaways

- NVMs are the future of neural interfaces
- We propose swapping as a power optimization
- Exploring both algorithms and devices
- Translate theory to practice





Questions?



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