



Cassiopeia Project

# ***The Neuromorphic Advantage***

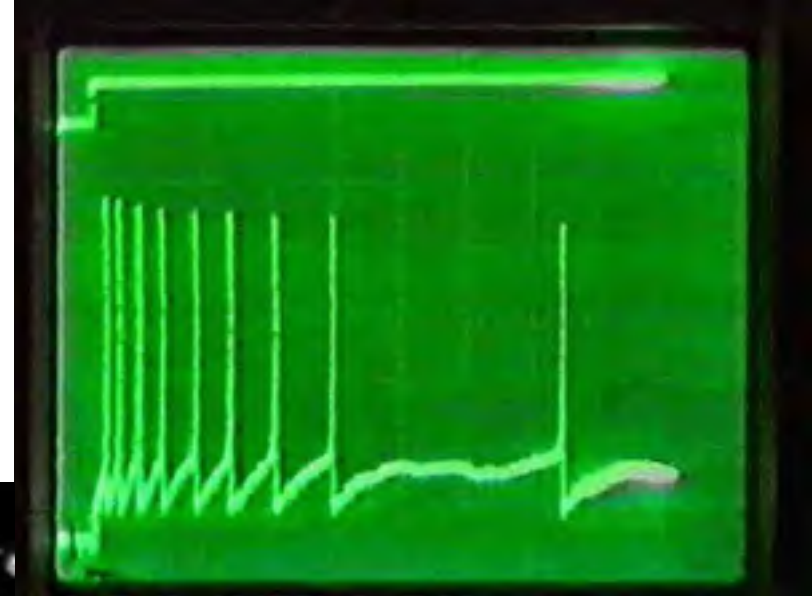
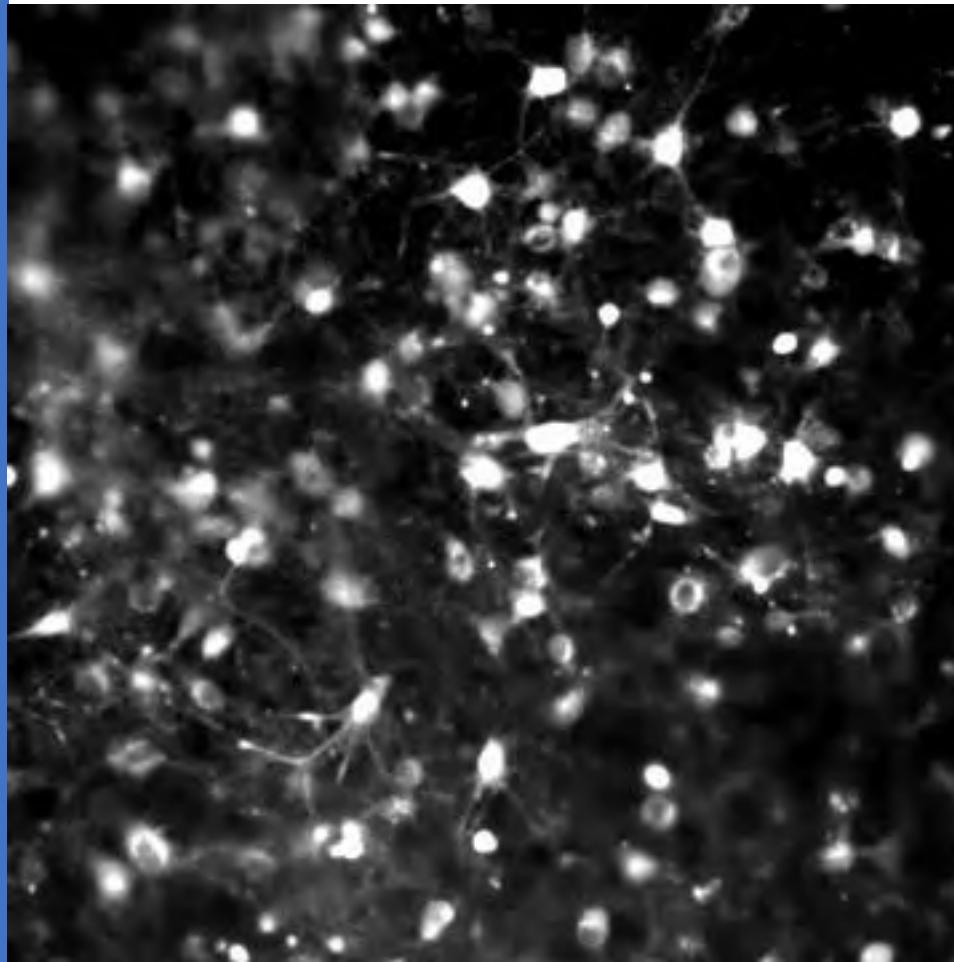
***Efficient Spiking Neural  
Networks for Dynamic Edge AI***



Chris Eliasmith, co-CEO  
Peter Suma, co-CEO

**(Biological)  
Neural  
Computation**

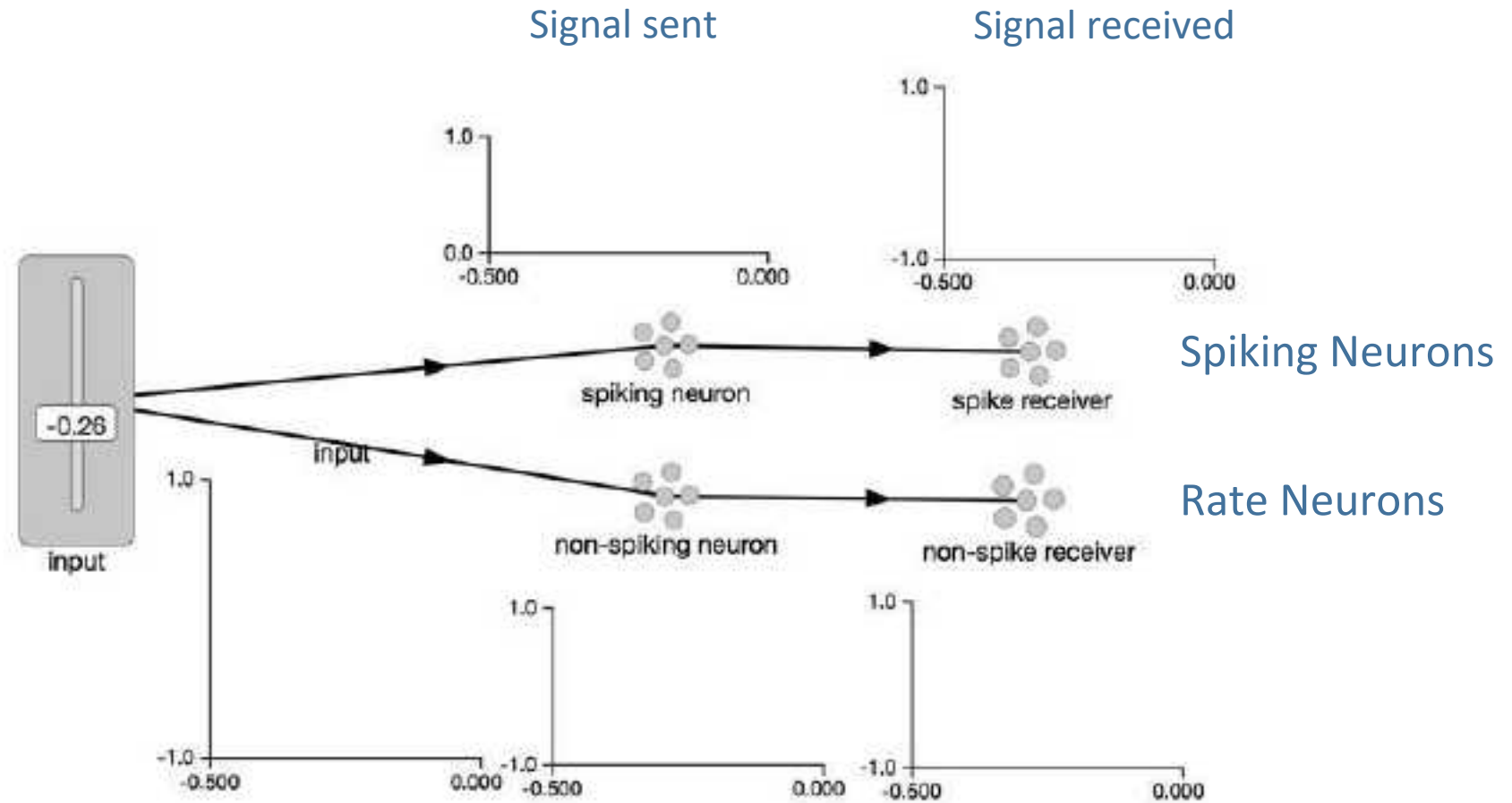
Neurons *Spike*



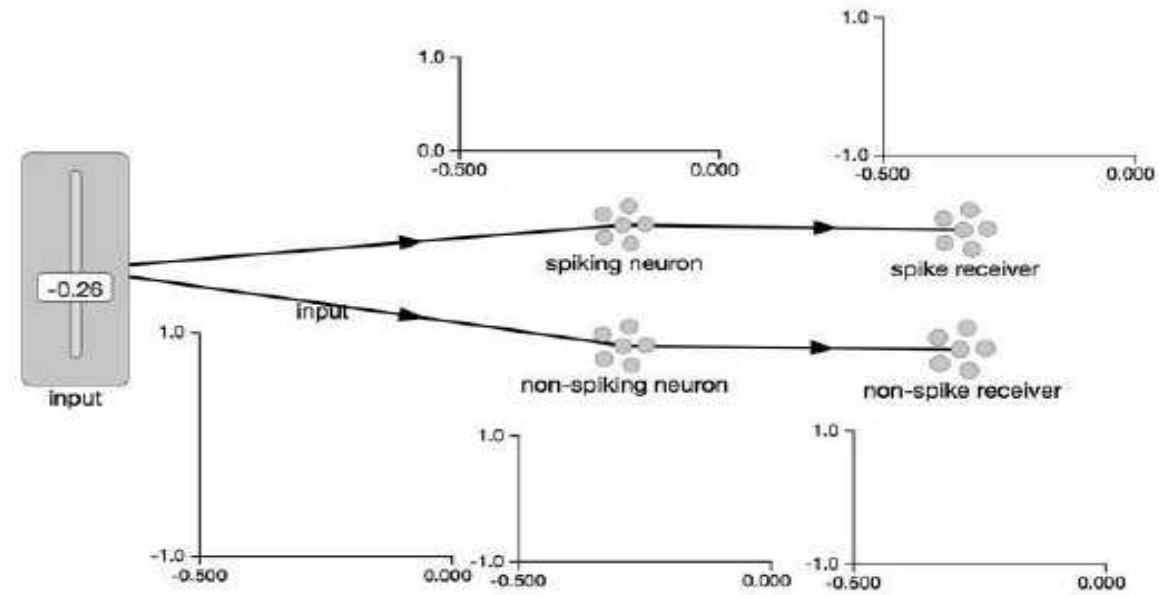
Spikes happen  
*in time*

**So What?**

# Neuromorphic Computing



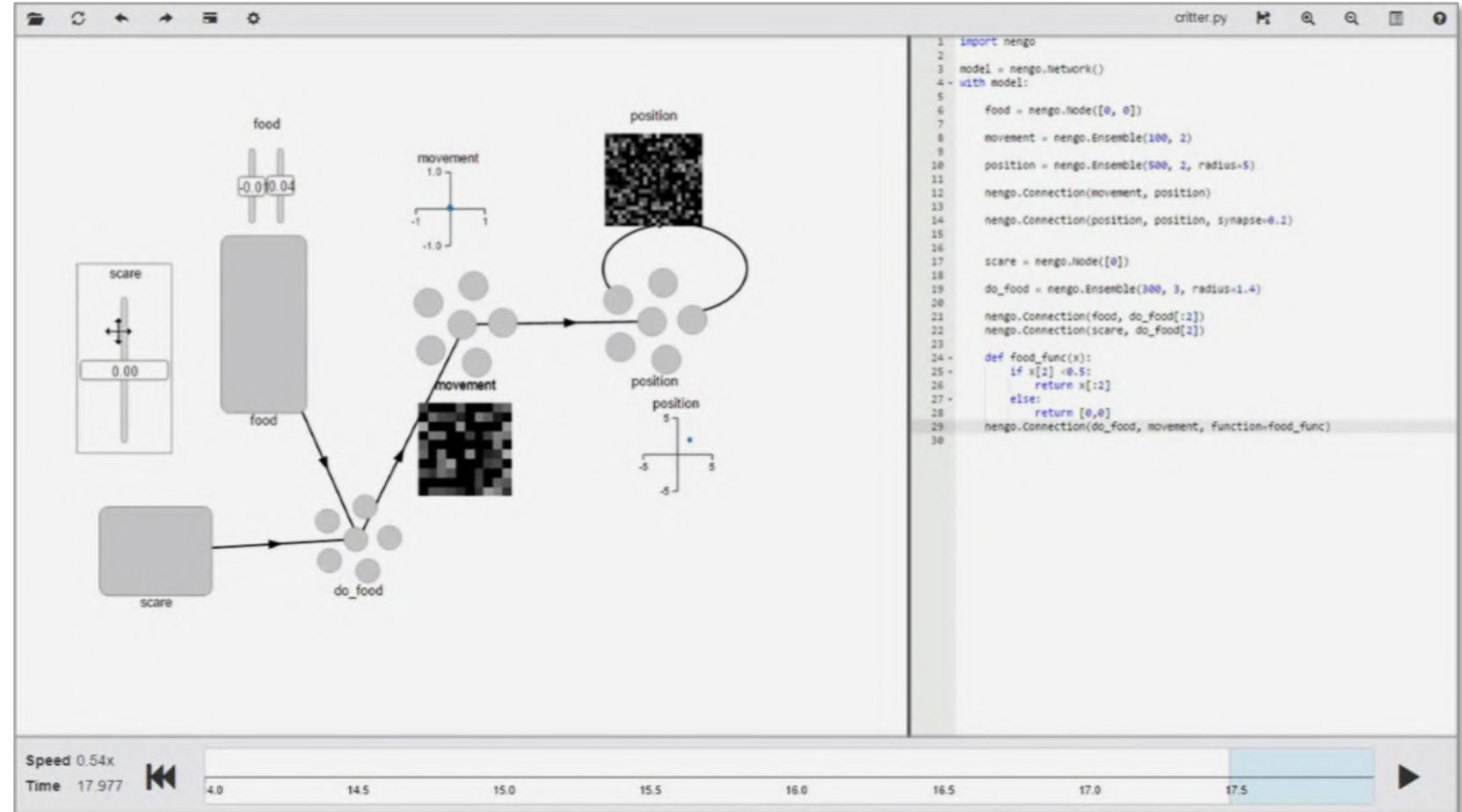
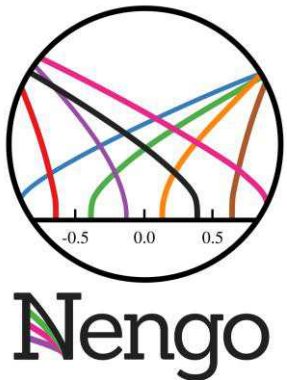
# Neuromorphic Advantages



- Sparsification over time
  - Less communication
- Less computation
  - Fewer memory lookups
- Cheaper computation
  - Sum instead of multiply

**So What?**

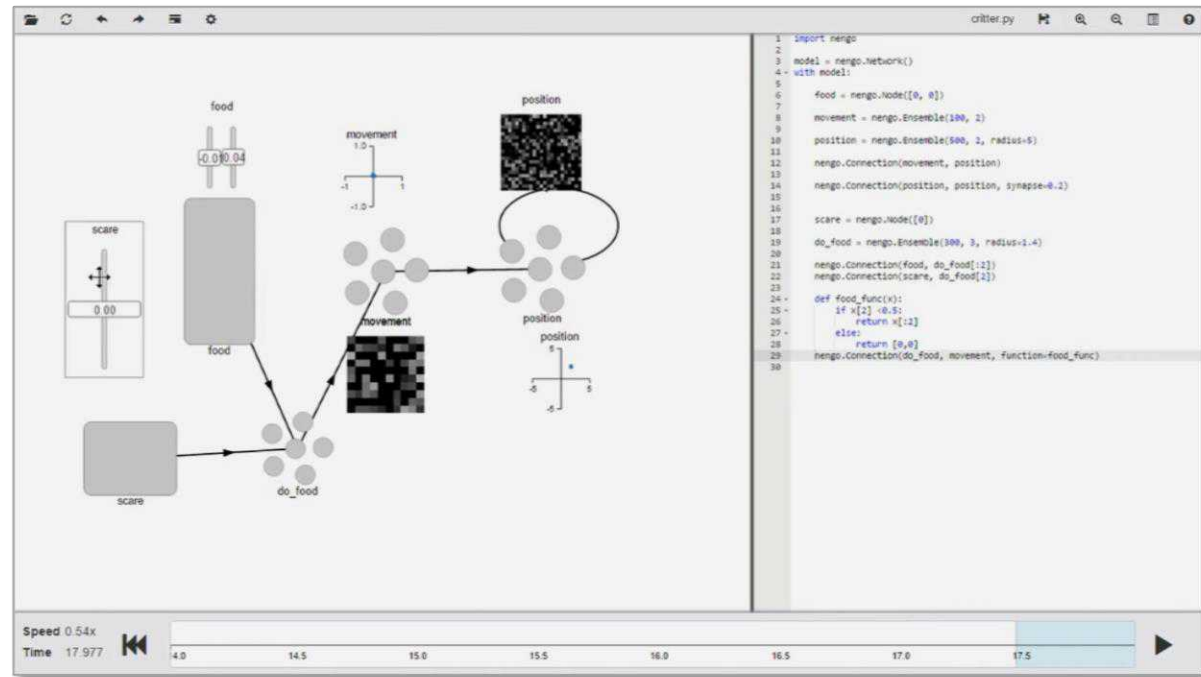
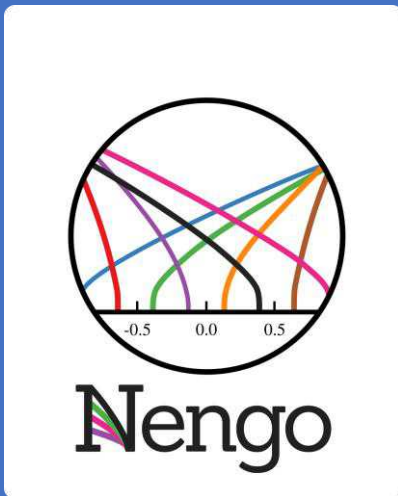
# Neuromorphic Development Environment (NDE)

The screenshot shows the Nengo Development Environment (NDE) interface. On the left, a diagram illustrates a neural network model with components: 'food' (a vertical bar with two input lines), 'scare' (a vertical bar with a central dot), 'do\_food' (a cluster of nodes), 'movement' (a square with a grid pattern), and 'position' (a square with a grid pattern). Arrows indicate connections between these components. On the right, a code editor displays Python code for a Nengo model. The code defines a network with nodes for 'food', 'movement', 'position', 'scare', and 'do\_food', and connections between them. A function 'food\_func' is defined to process the 'do\_food' node's output. The bottom of the interface shows a speed control set to 0.54x and a time slider ranging from 4.0 to 17.5.

```
1 import nengo
2 model = nengo.Network()
3 with model:
4     food = nengo.Node([0, 0])
5     movement = nengo.Ensemble(100, 2)
6     position = nengo.Ensemble(500, 2, radius=5)
7     nengo.Connection(movement, position)
8     nengo.Connection(position, position, synapse=0.1)
9     scare = nengo.Node([0])
10    do_food = nengo.Ensemble(300, 3, radius=1.4)
11    nengo.Connection(food, do_food[:2])
12    nengo.Connection(scare, do_food[3])
13
14    def food_func(x):
15        if x[2] < 0.5:
16            return x[:2]
17        else:
18            return [0, 0]
19    nengo.Connection(do_food, movement, function=food_func)
```

## Design & Integrate Spiking Neural Networks

# Neuromorphic Development Environment (NDE)



## Current Backends



(Conventional)

(Neuromorphic)

# Code Once, Run Anywhere

**So What?**

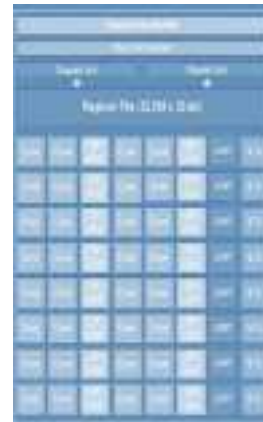
# Neuromorphic Processing Unit

**CPU**



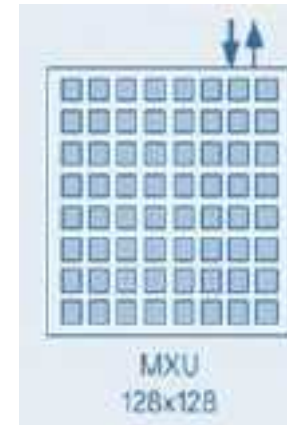
1971

**GPU**



1999

**TPU**



2016

**NPU**



2021



Low

Compute Parallelism, Temporal Sparsity & Scalability

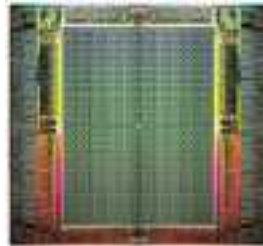
High

High

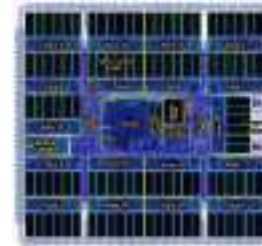
Compute Energy per inference

Low

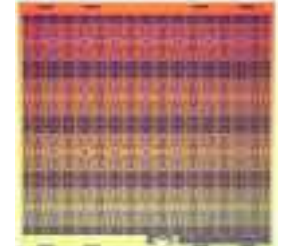
# Neuromorphic Hardware



**ABR FPGA**  
**2019 – Small Shipping**  
**2020 - Large**



**ABR Nengo**  
**Brain Chip**  
**Early 2021**



**Intel Loihi**  
**Research Chip**

**So What?**

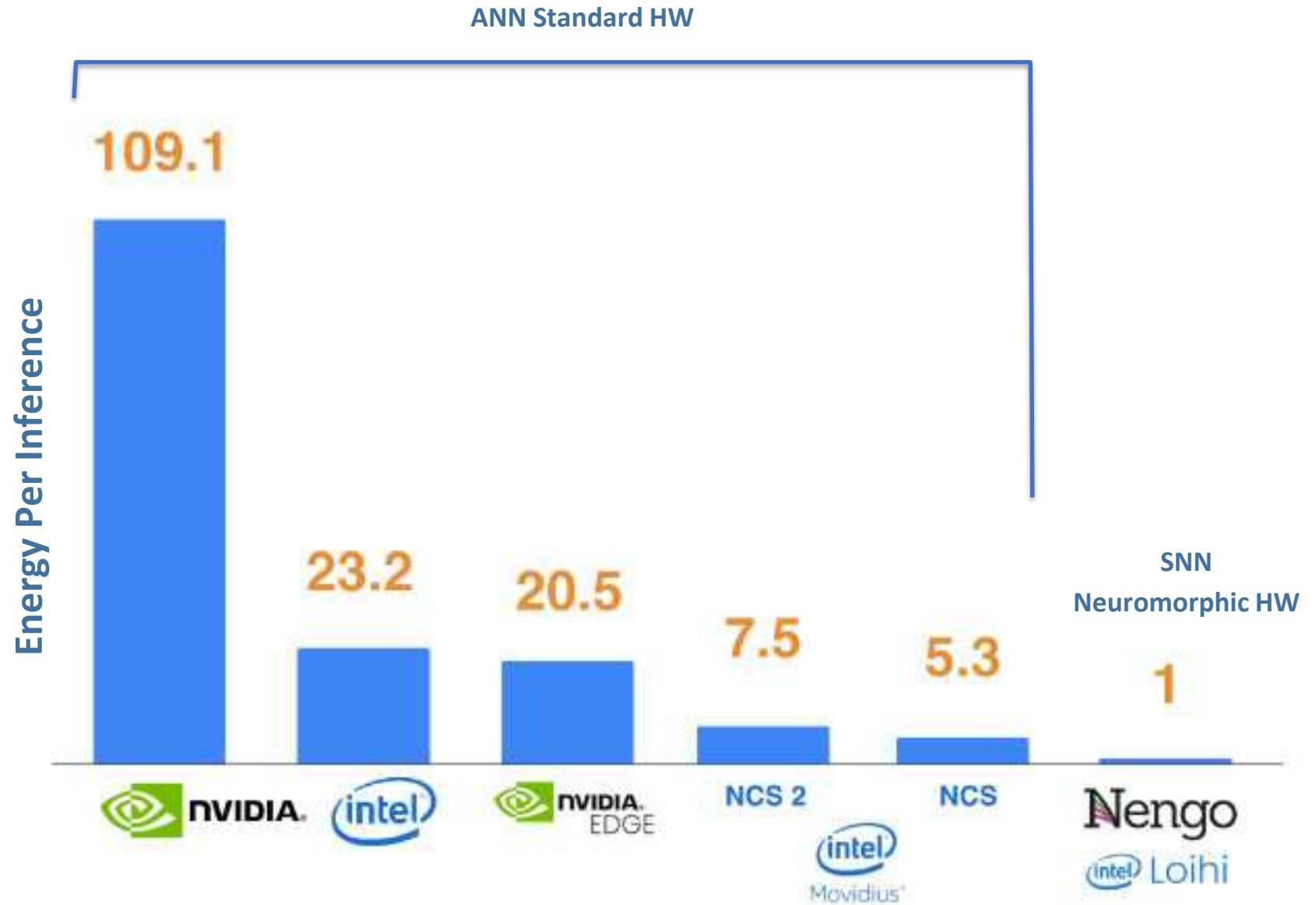
# A Note on Measuring AI Hardware Performance

All of our results are:

*implemented and measured on real neuromorphic hardware*

- This is uncommon
- Critical because:
  - Captures *real-world* deployment
  - Results from *full system* optimization
  - Avoids notoriously poor TOPS/W comparisons

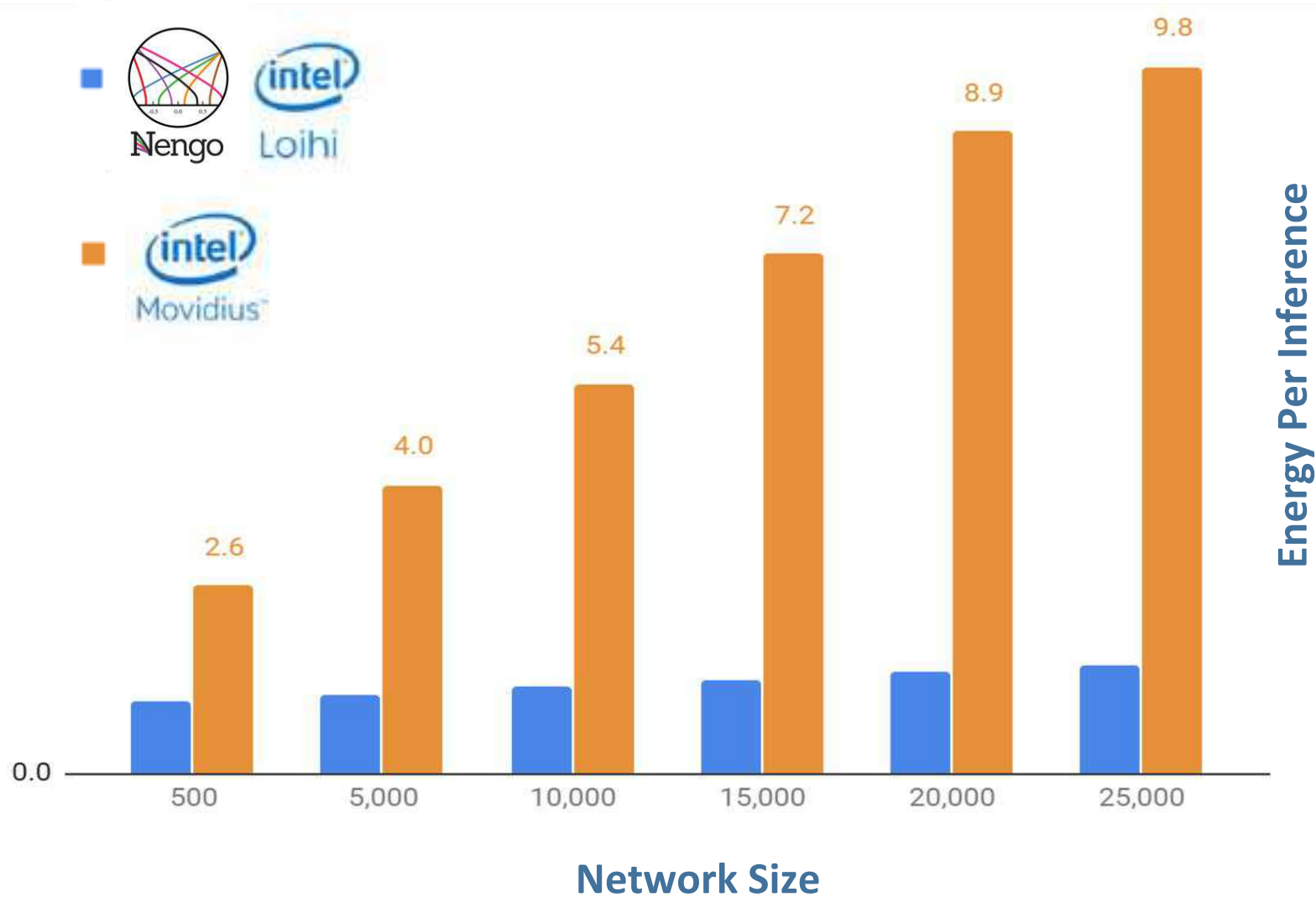
# Neuromorphics: Deep Networks Lower Power



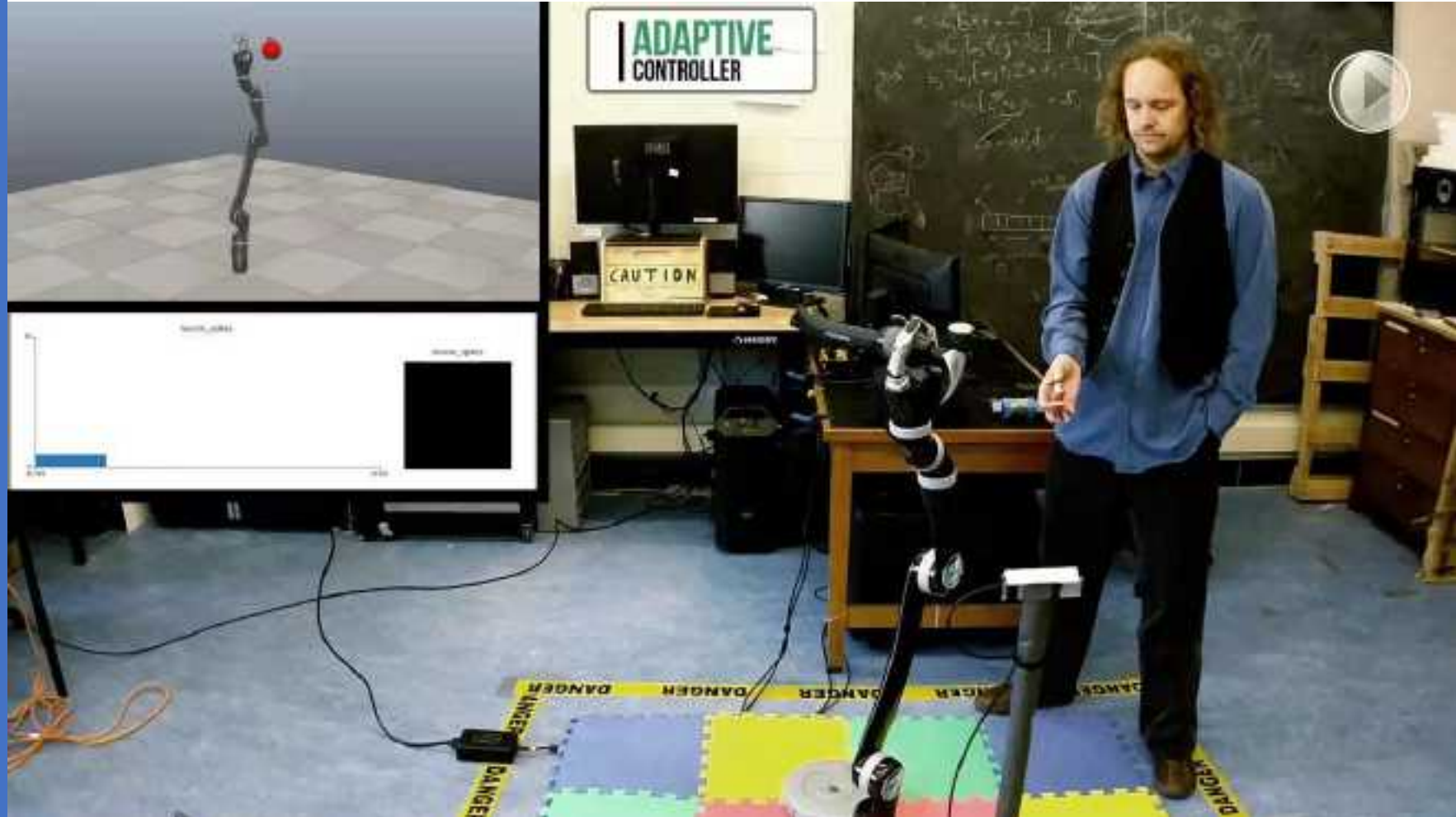
ANN Accuracy – 92.7%

SNN Accuracy – 93.8%

# Neuromorphics: Superior Scaling

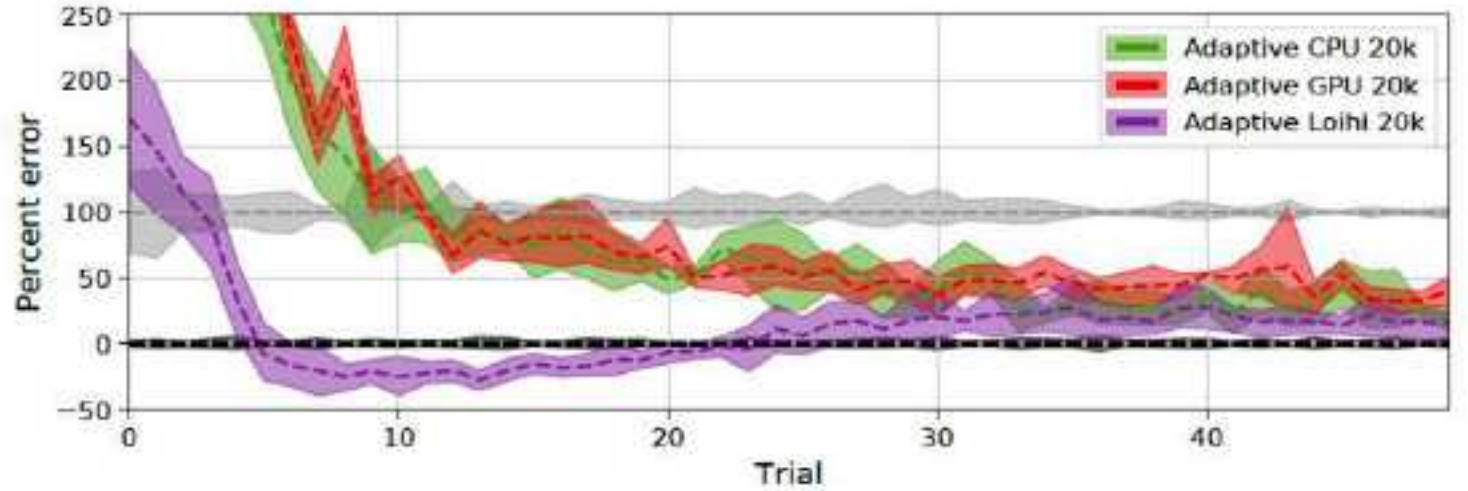


# Application: Adaptive Control

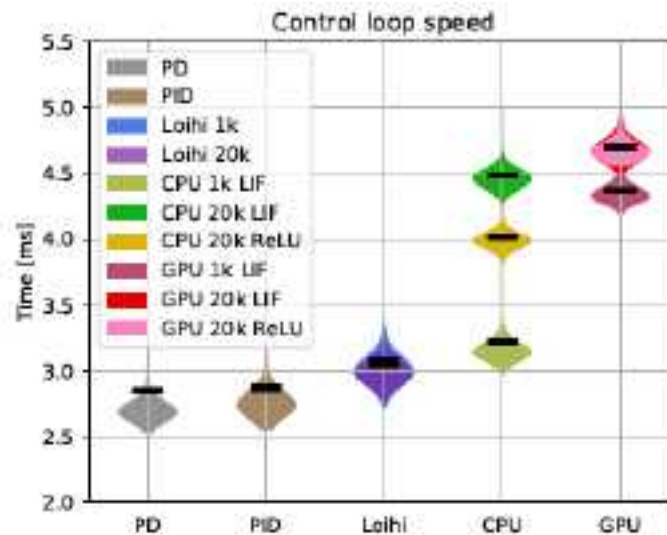


Online Learning for Visually Guided Reaching

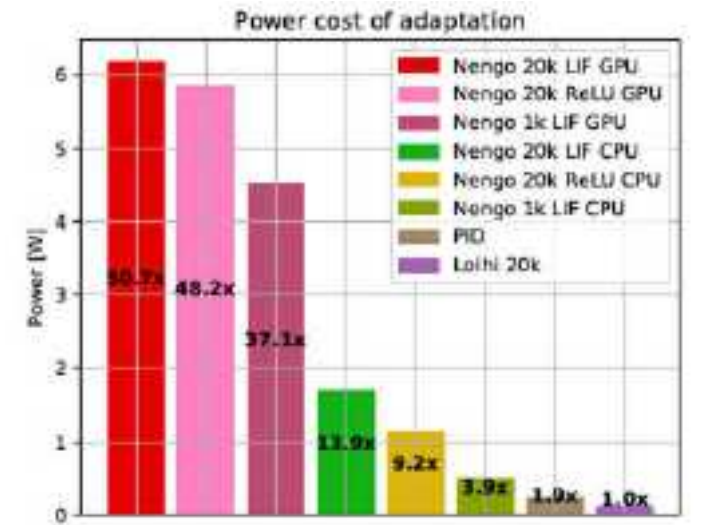
Neuromorphics:  
 More accurate  
 Faster  
 Lower power



Accuracy (~same)



Speed (25-35%)



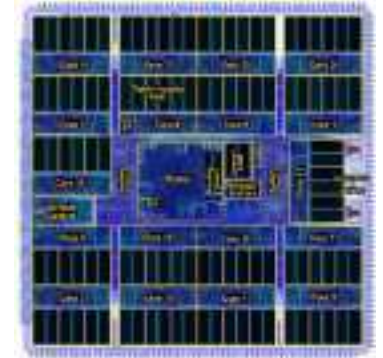
Power (10-50x)

**What's Next?**

# ABR Nengo Brain Chip

## Proven Technology

- Building off SpiNNaker 2



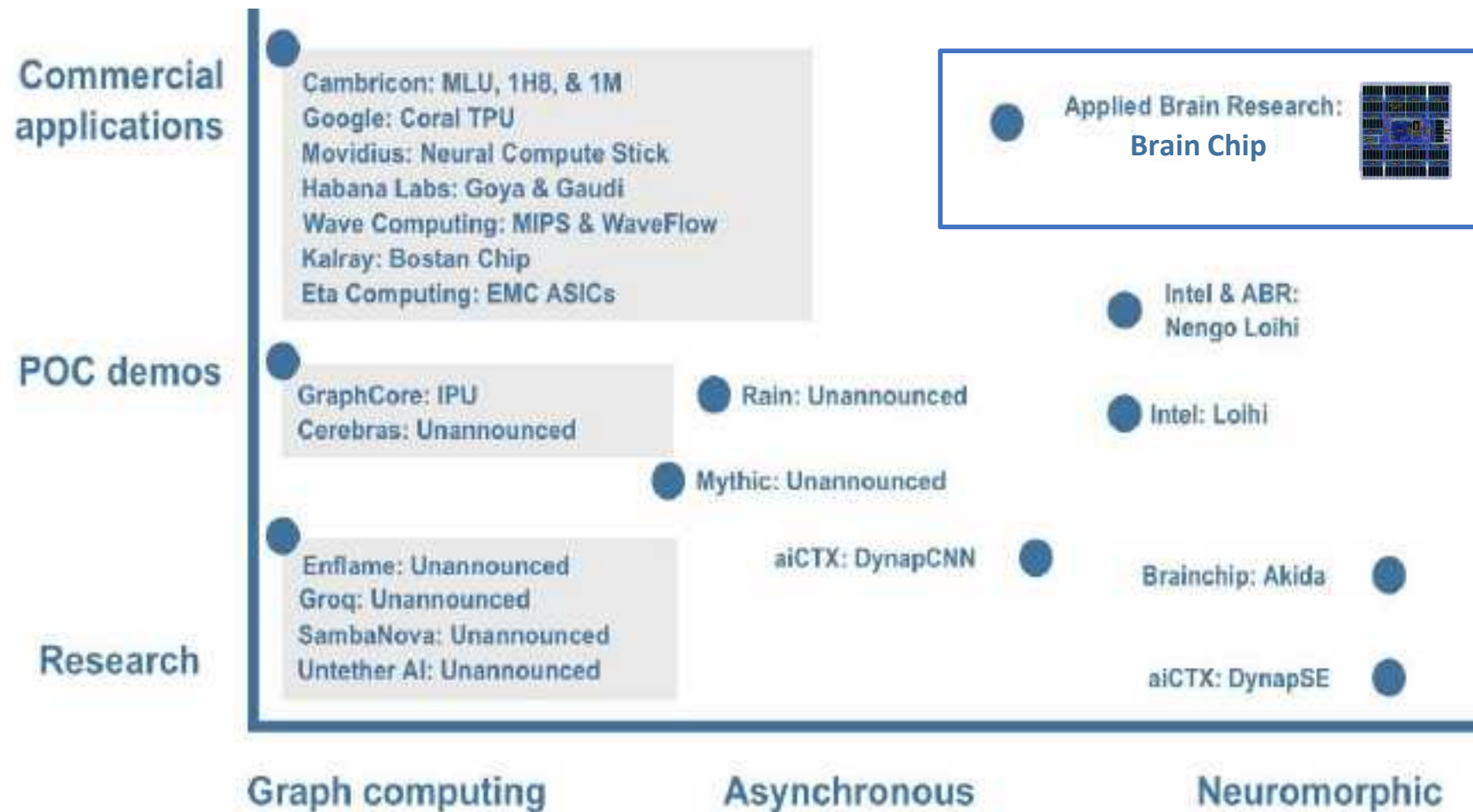
## Low Power

- FD-SOI CMOS with adaptive body biasing to operate at low energy
- Dynamic source voltage and clock speed management driven by computational load

## Flexible

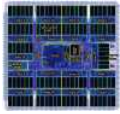
- *Hybrid* spiking and non-spiking design
- Enables task specific optimization

# Neural Network Hardware Landscape



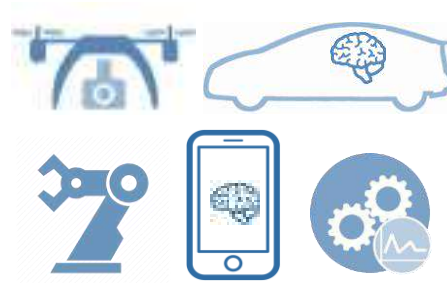


## AI TOOLS



Nengo

NDE, Libraries  
& AI Chips



## AI BRAINS

Voice, Video, Control, Security  
for Cars, Smartphones, Drones,  
Robots, IoT

GLOBAL  
AUTO  
MAKER

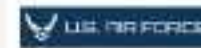
LEADING  
PHONE  
MAKER

TOP 5 ENERGY  
COMPANY



## AI R&D

Dynamic, Full-loop,  
Cognitive AI





# Building Neuromorphic Brains for Low power, Dynamic, Edge AI

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