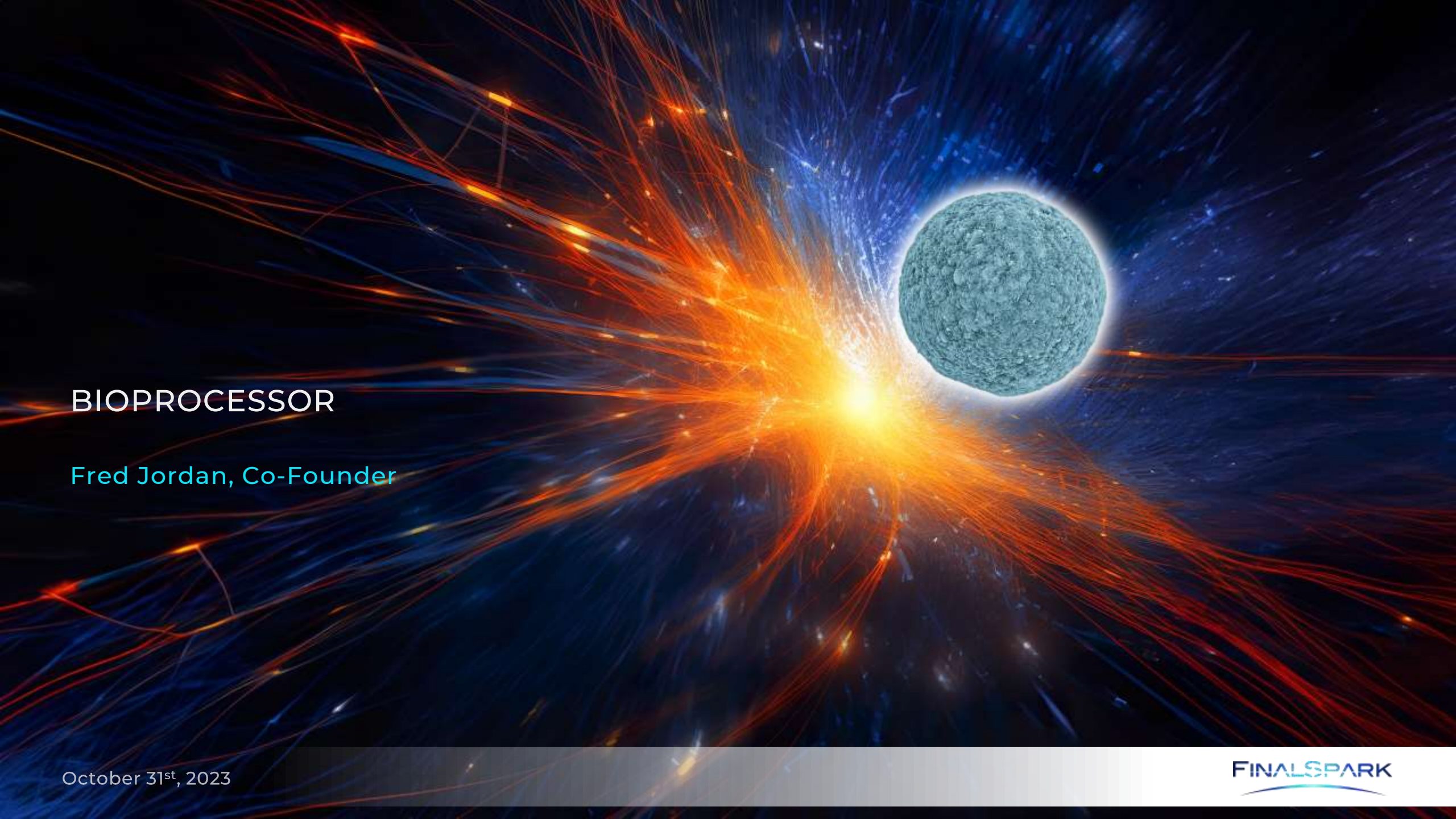

BIOPROCESSOR

Fred Jordan, Co-Founder

October 31st, 2023

FINALSPARK

ABOUT FINALSPARK

Fundamental research in strong AI since 2014

Switch to biocomputing approach in 2018

Swiss Headquarters

Dr Fred Jordan
PhD, signal processing

Dr Martin Kutter
PhD, signal processing

Jean-Marc Comby
MSc in physics

Dr. Ewelina Kurtys
PhD, neuroscience

Flora Brozzi
PhD, biology

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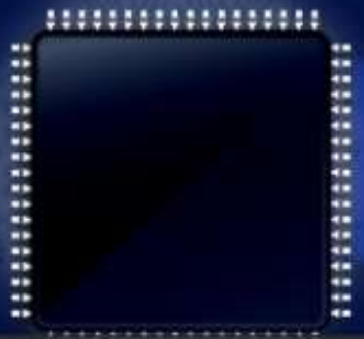
FROM DIGITAL TO BIO



Digital Processor

Today, AI growth is limited by high energy use required

Bioprocessor

AI growth will be enhanced with no energy restrictions

WHY LIVING NEURONS?

Because it works

WHY LIVING NEURONS?

Because it works

Because it’s 1 million times more energy efficient

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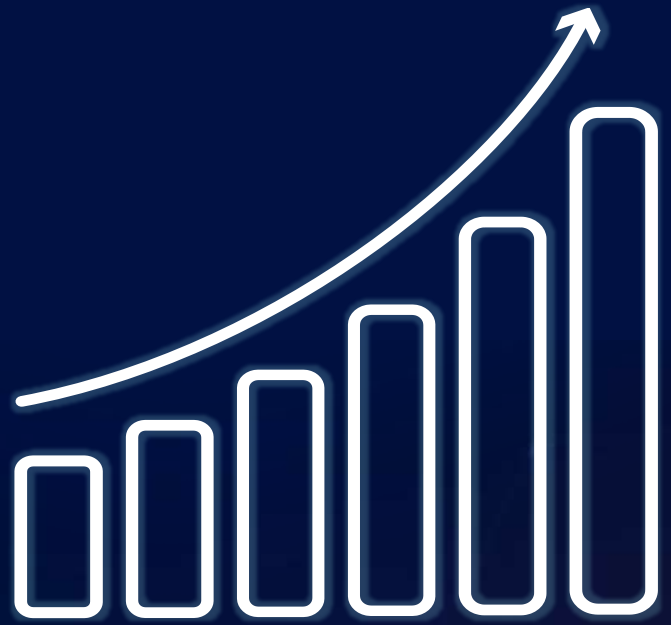
WHY LIVING NEURONS?

Because it works

Because it’s 1 million times more energy efficient

Because it’s scalable



FOR WHAT PURPOSE?

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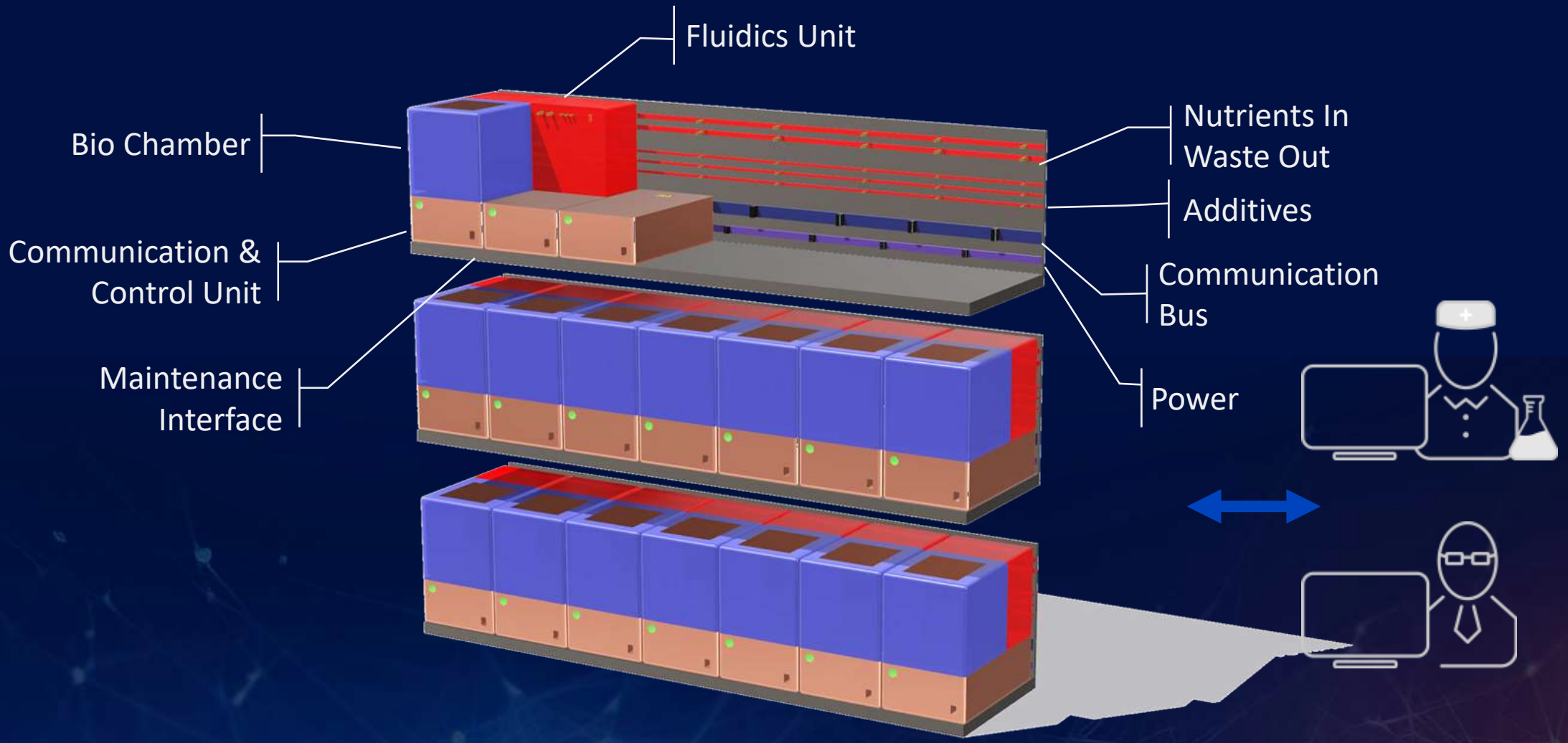
FROM BIOPROCESSOR TO BIOBLADE TO BIOFARM



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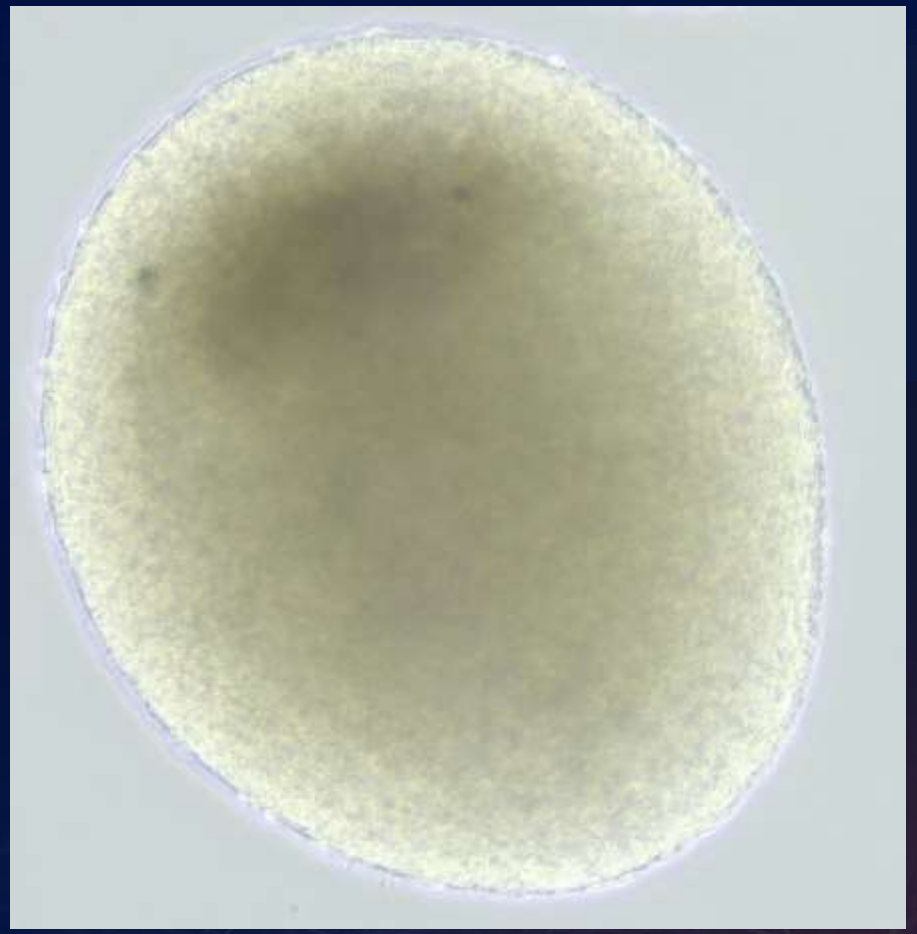
LIVING COMPUTER: BIOLOGICAL NEURAL NETWORKS

- Brain organoids
- Human IPSC
- ~500 um diameter



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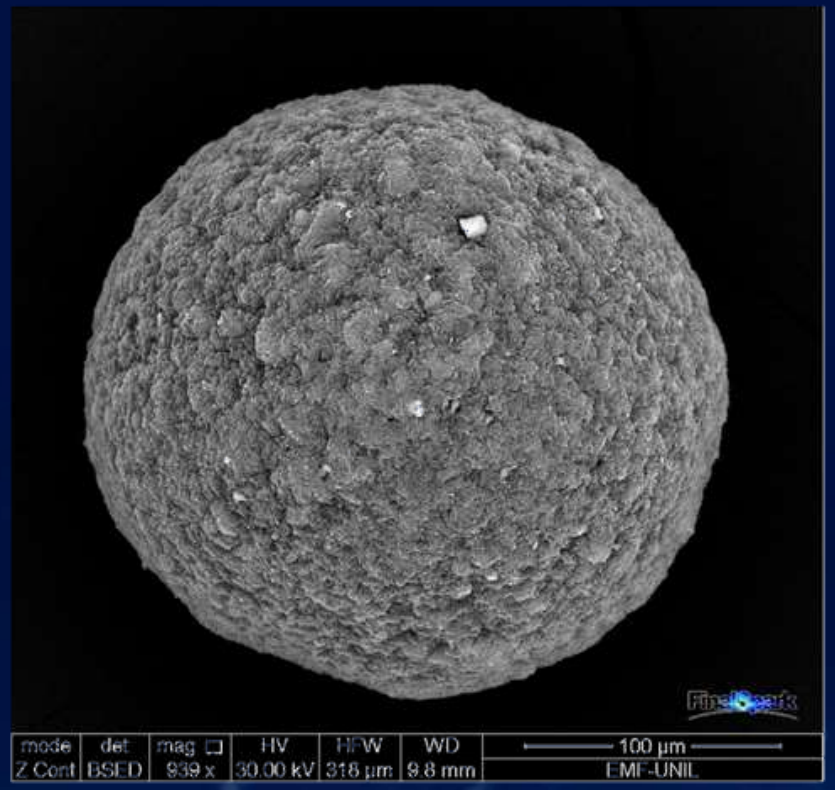
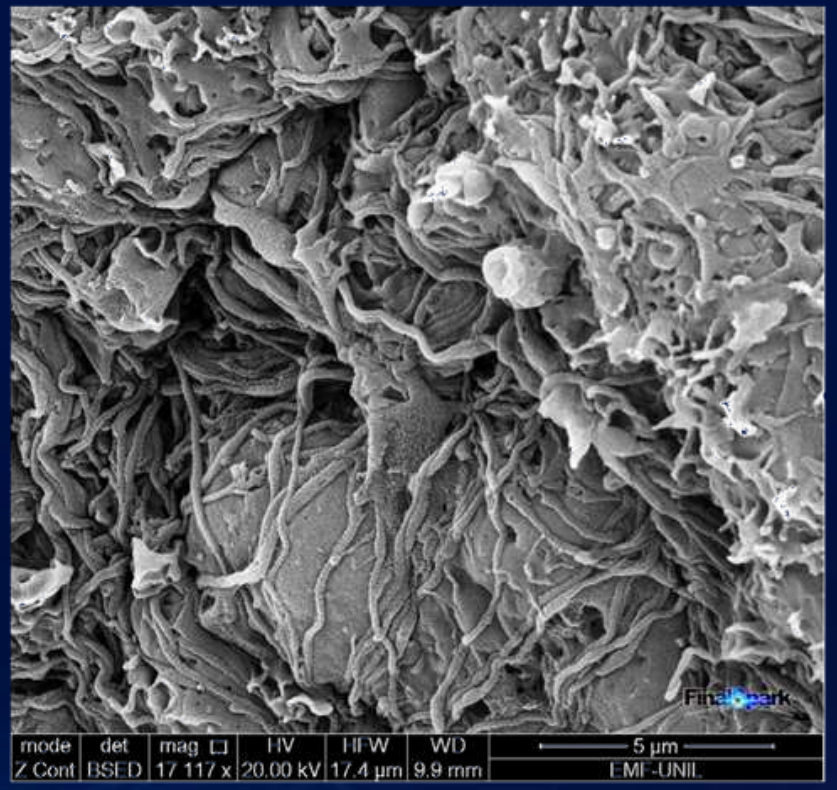
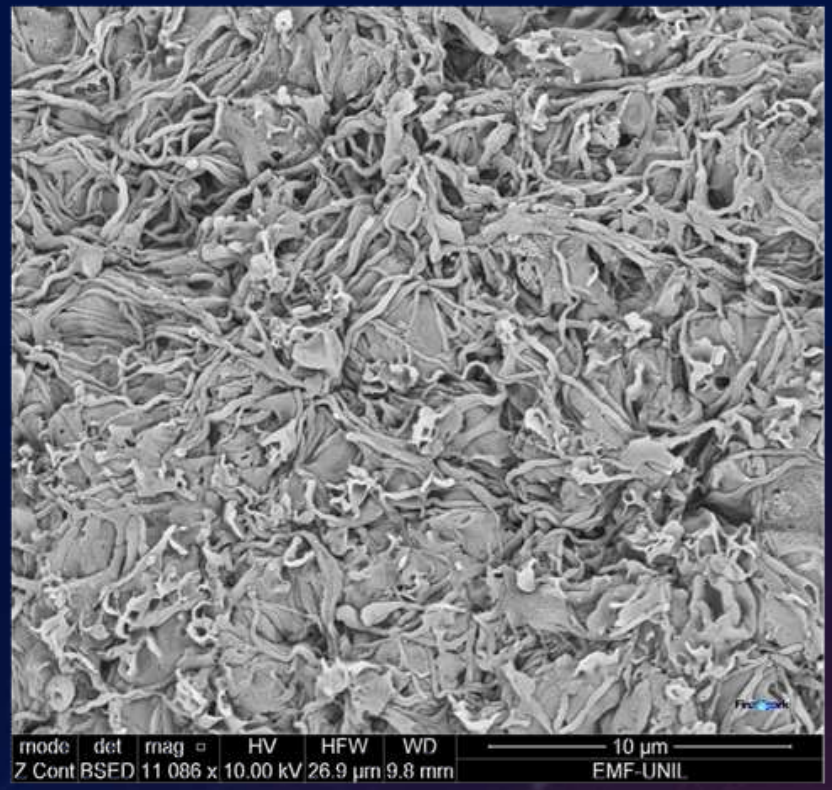
ONE OF OUR ORGANOIDS UNDER MICROSCOPE







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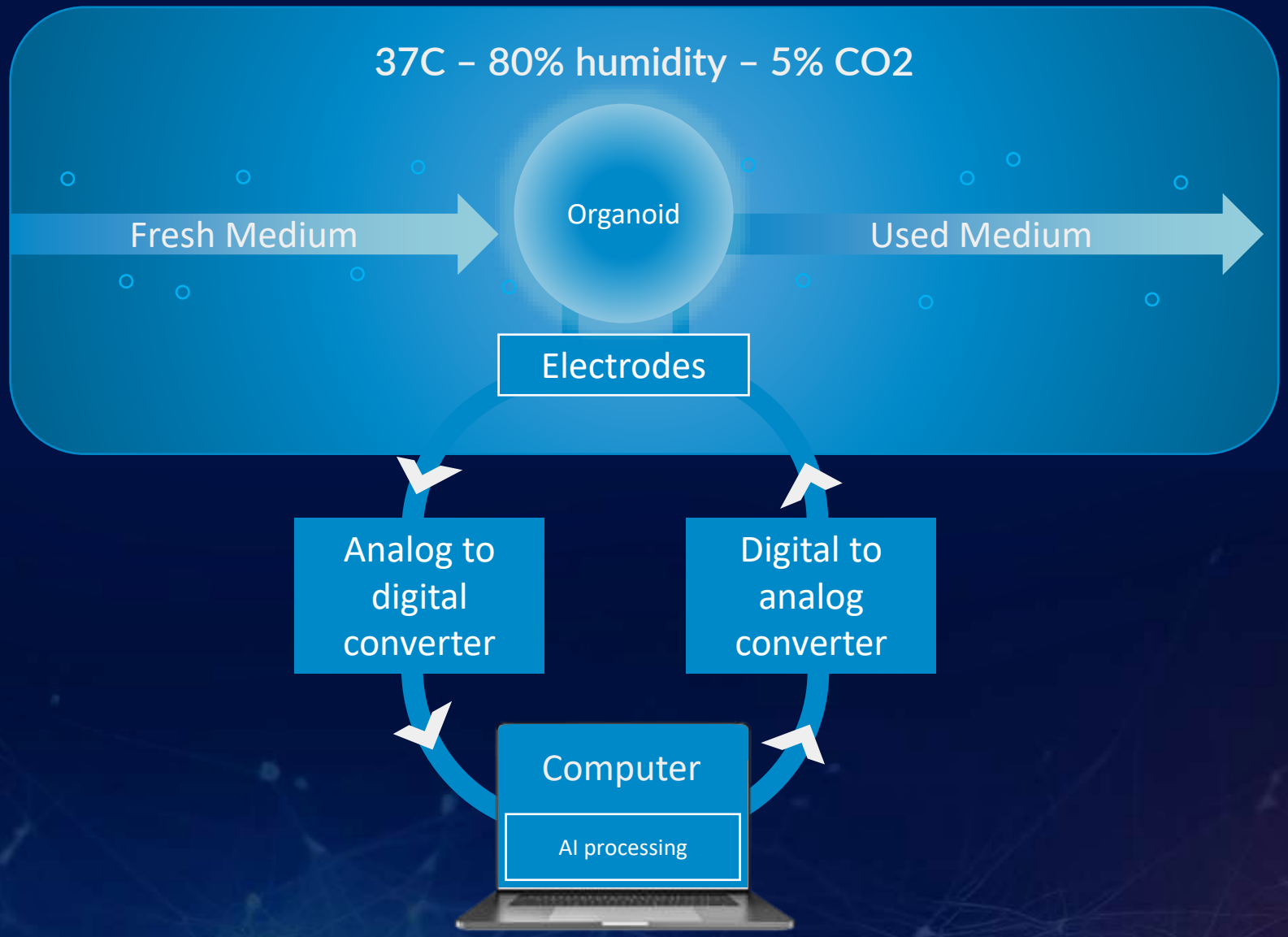
37C – 80% humidity – 5% CO2
Fresh Medium
Organoid
Used Medium
Electrodes
Analog to digital converter
Digital to analog converter
Computer
AI processing

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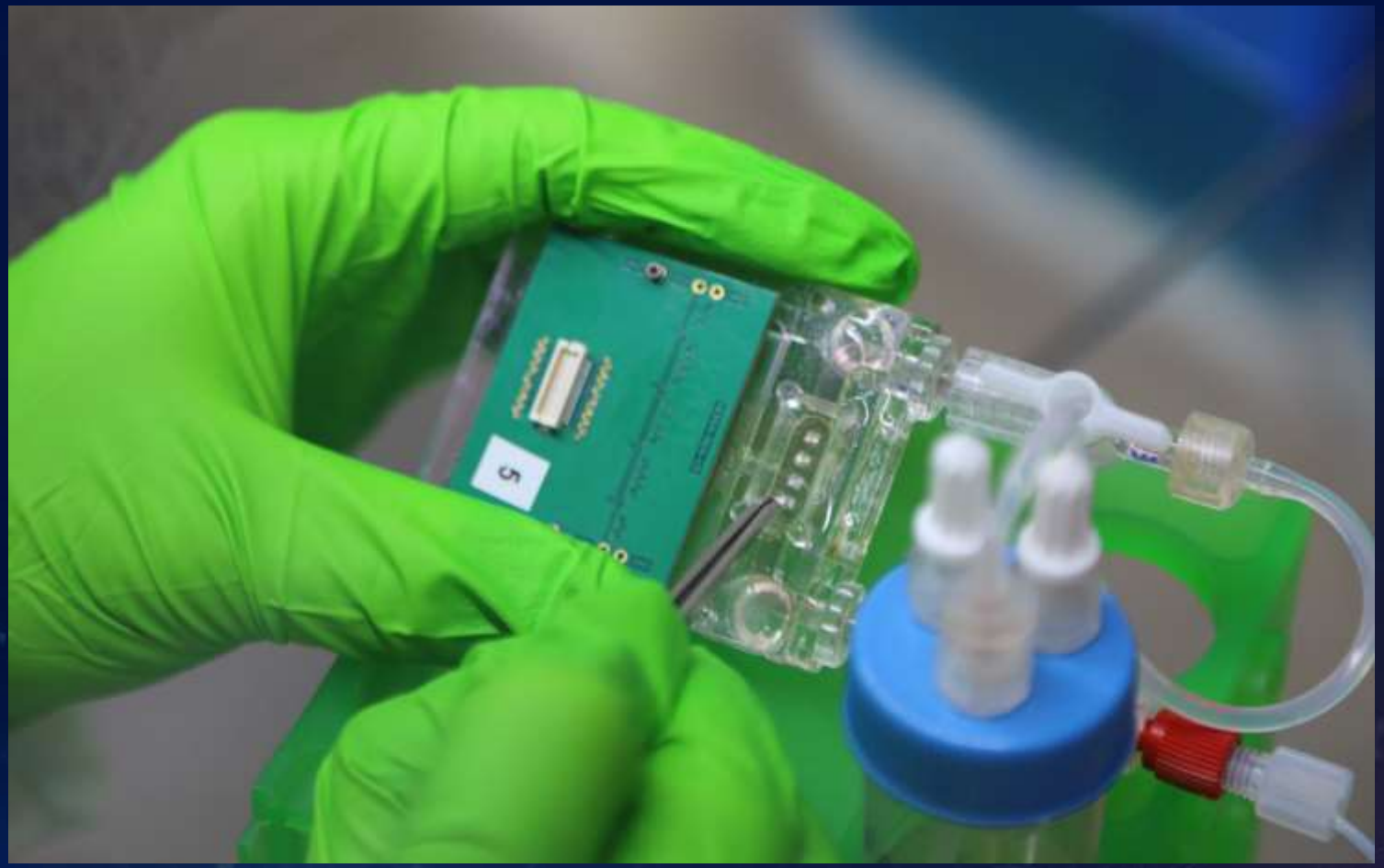
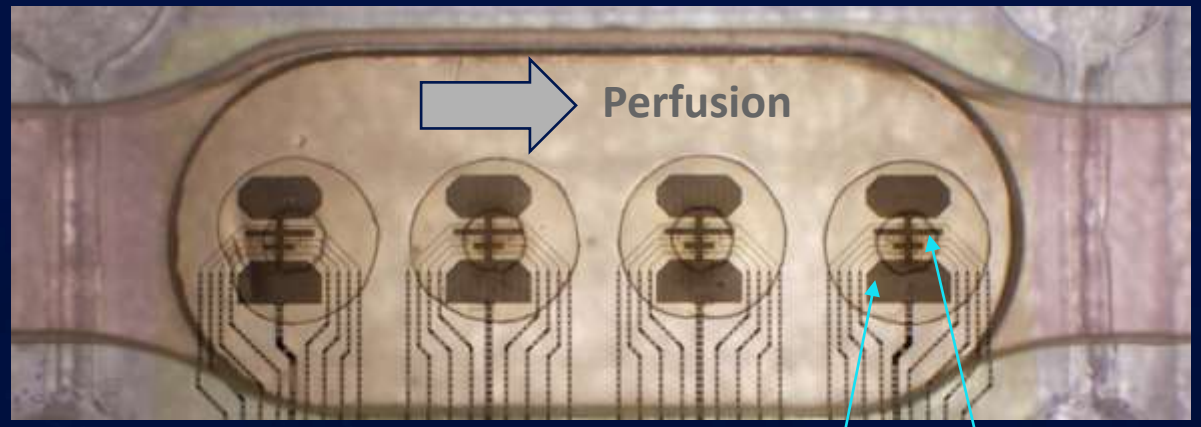
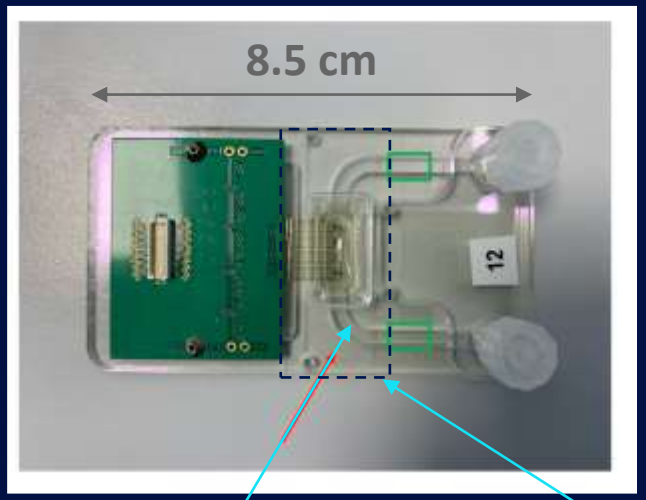
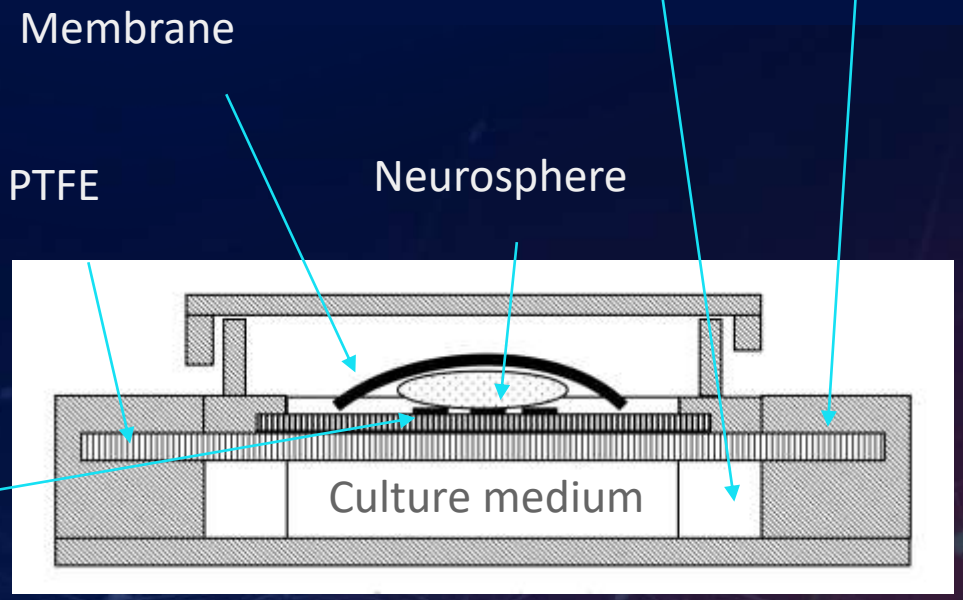
MULTI-ELECTRODE ARRAYS



BRAIN ORGANOIDS AND MEA







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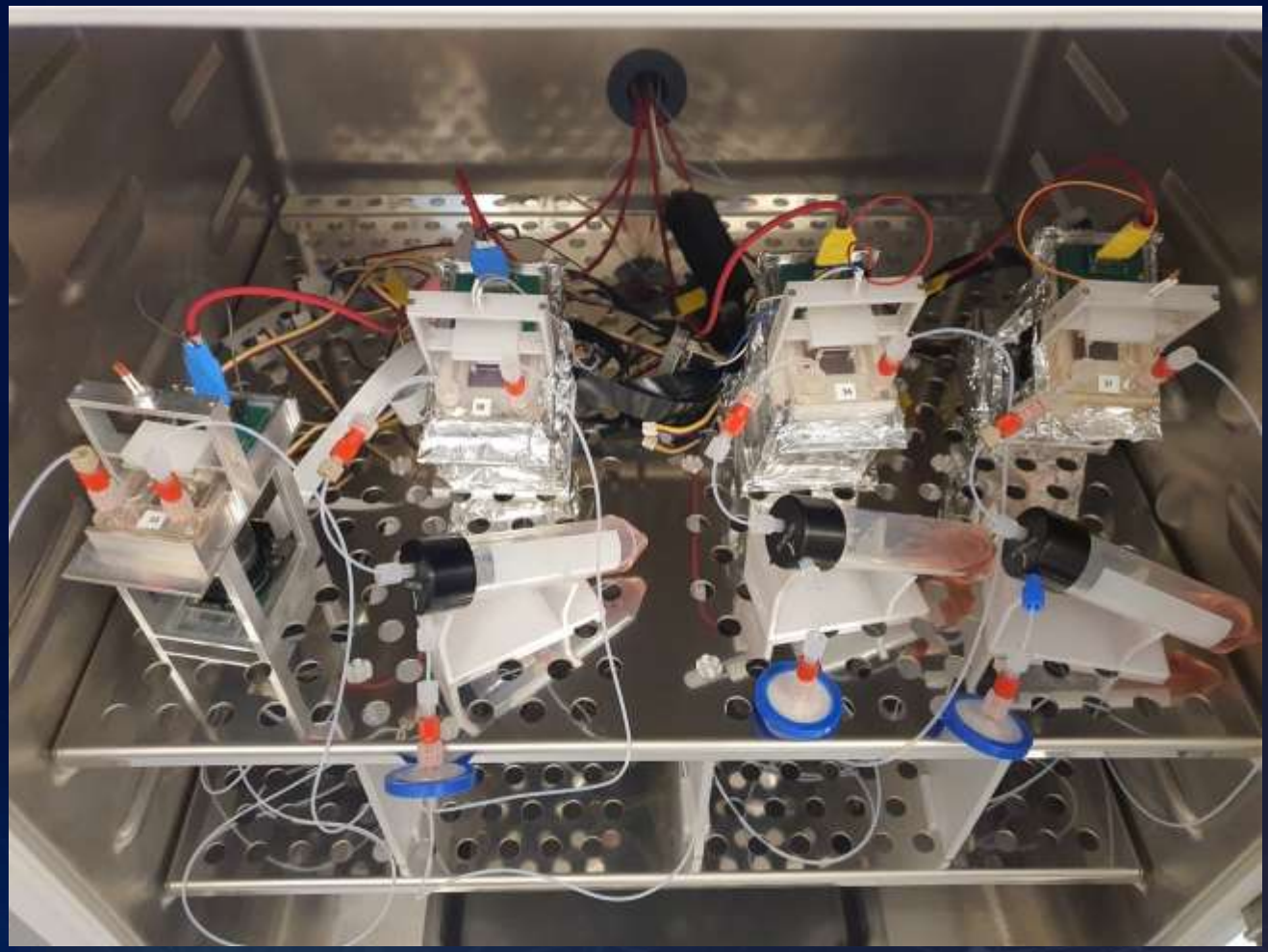
HOW DOES IT LOOK LIKE?



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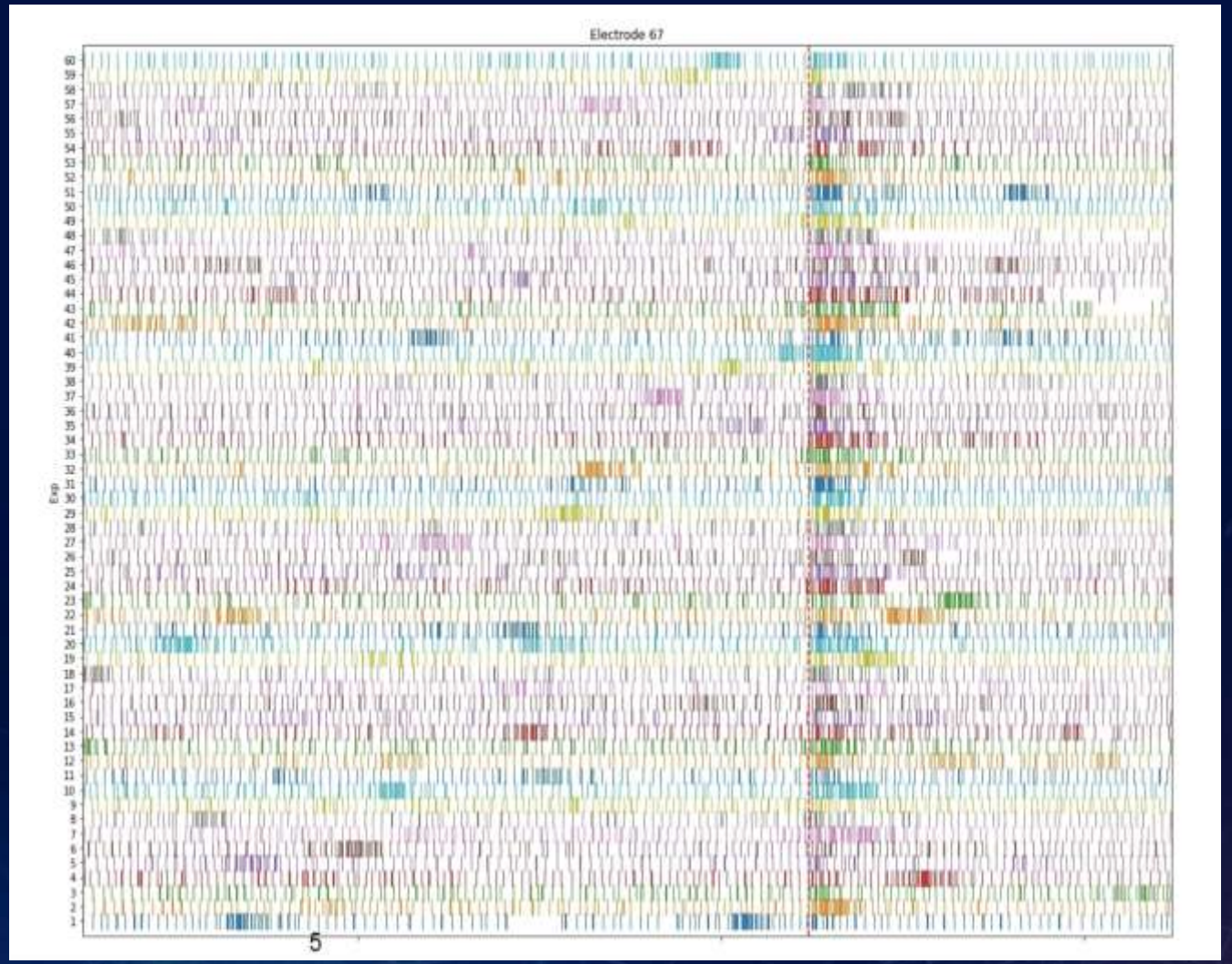
SIMPLE ELICITED SPIKES



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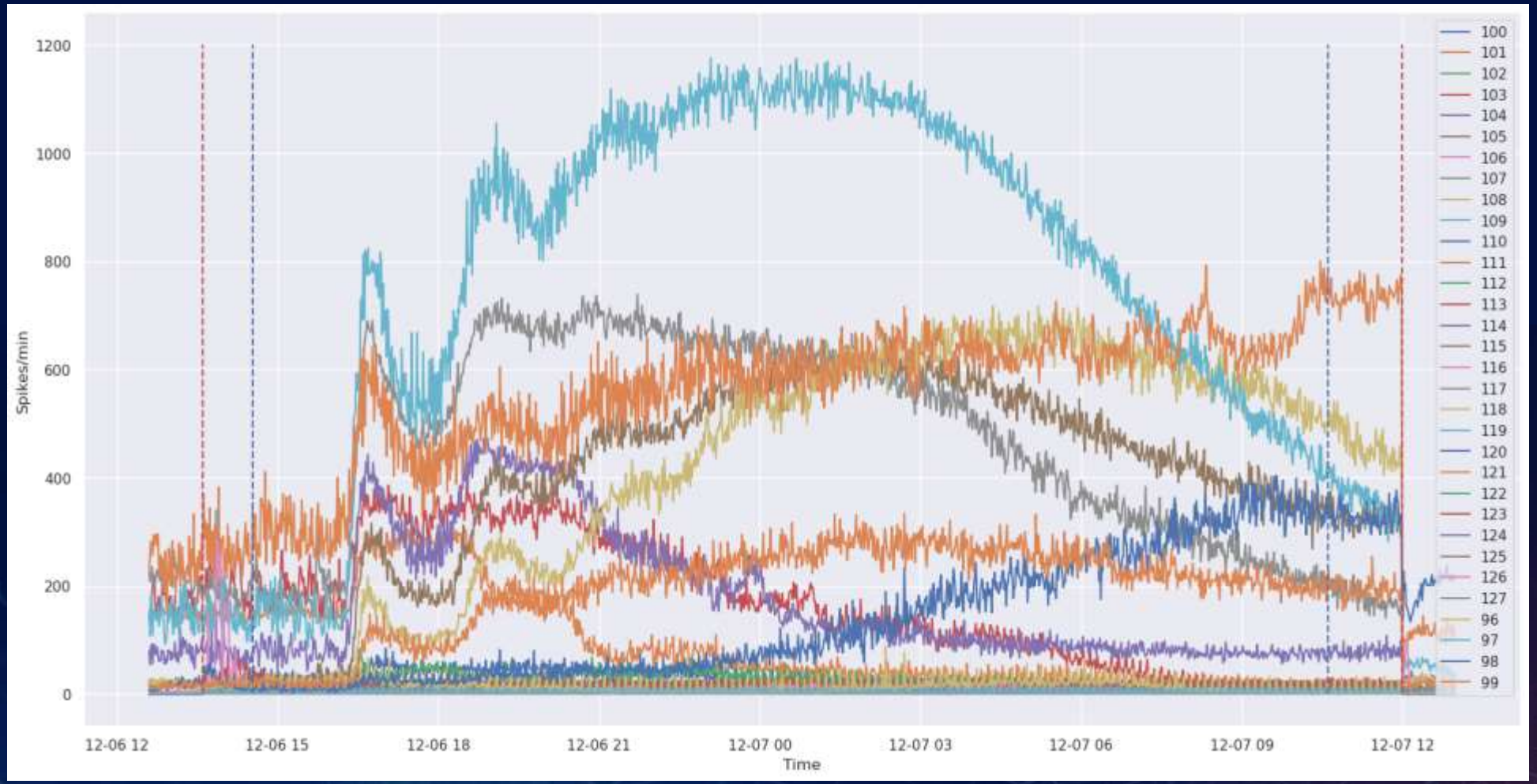
EFFECT OF NMDA INJECTION



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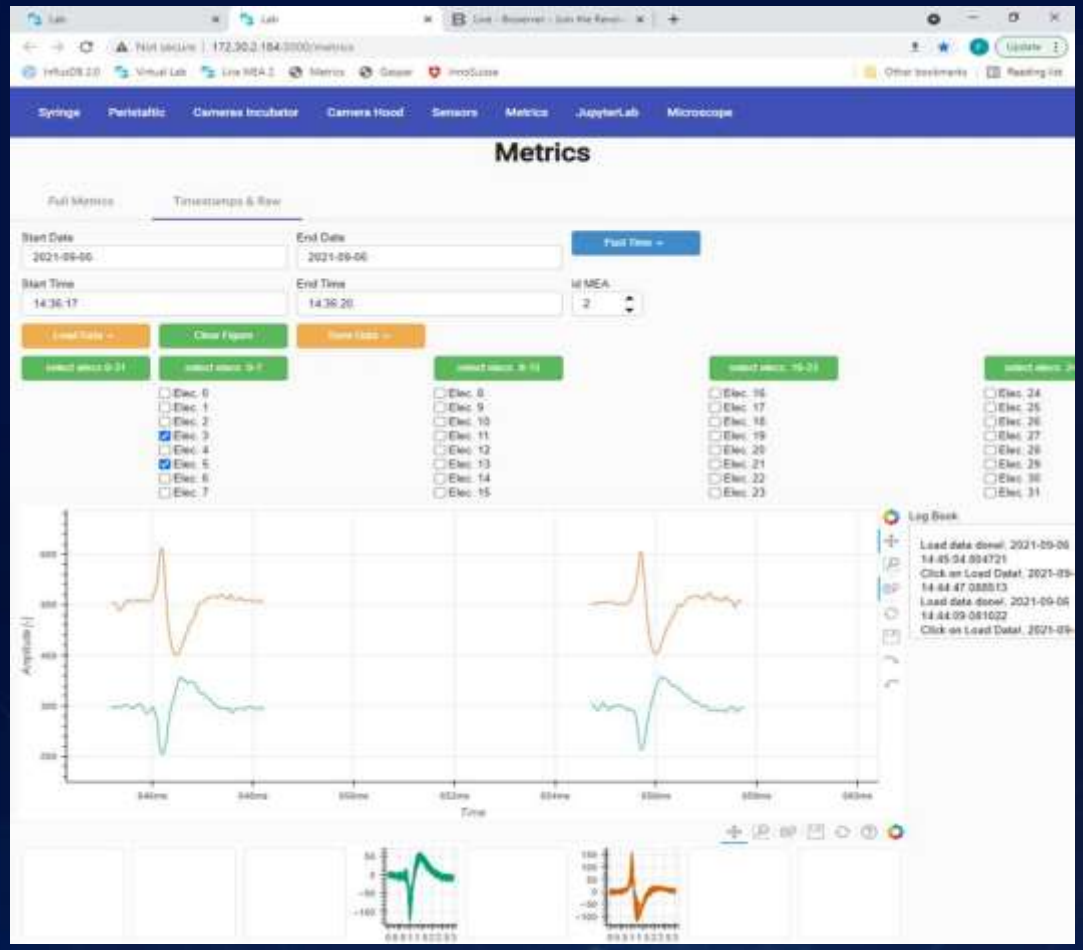
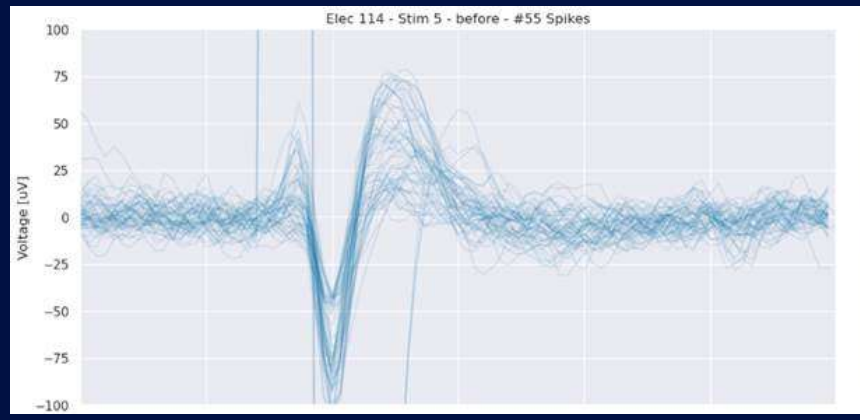
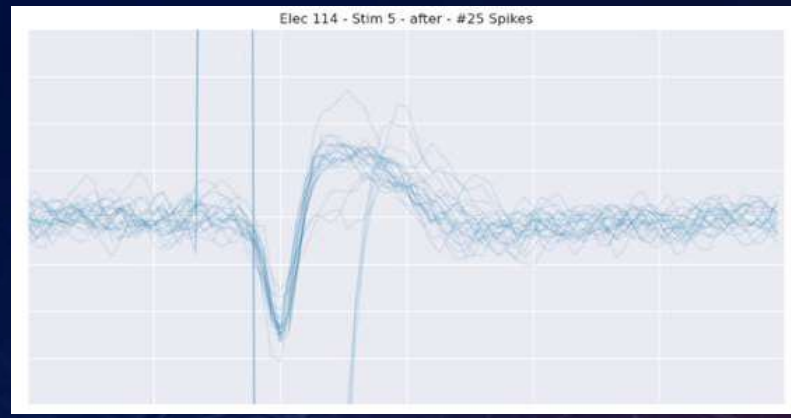
FULL SIGNAL







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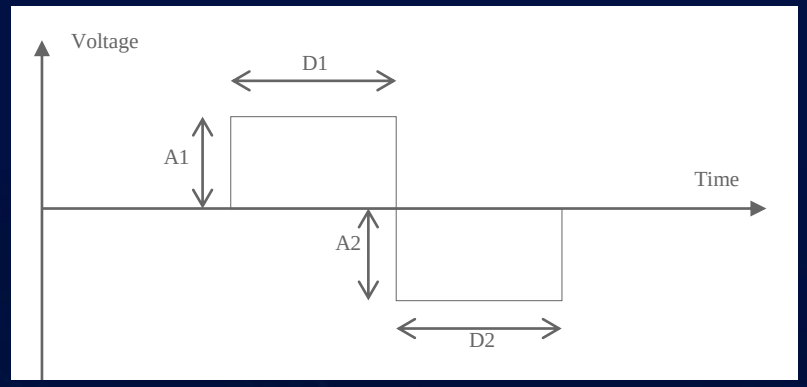
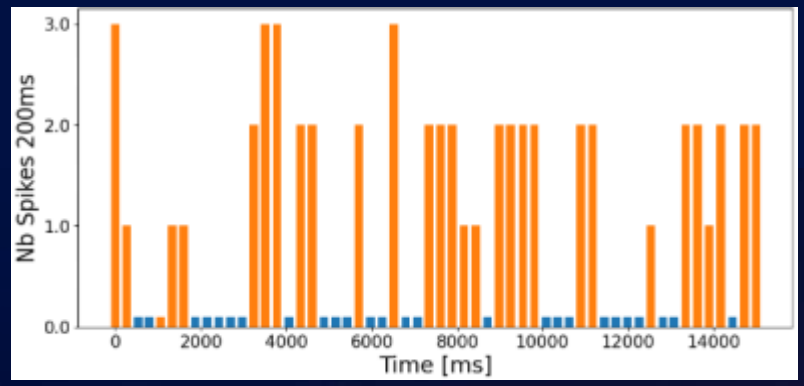
SIGNAL SHAPE MATTERS FOR RECEIVING ANSWERS





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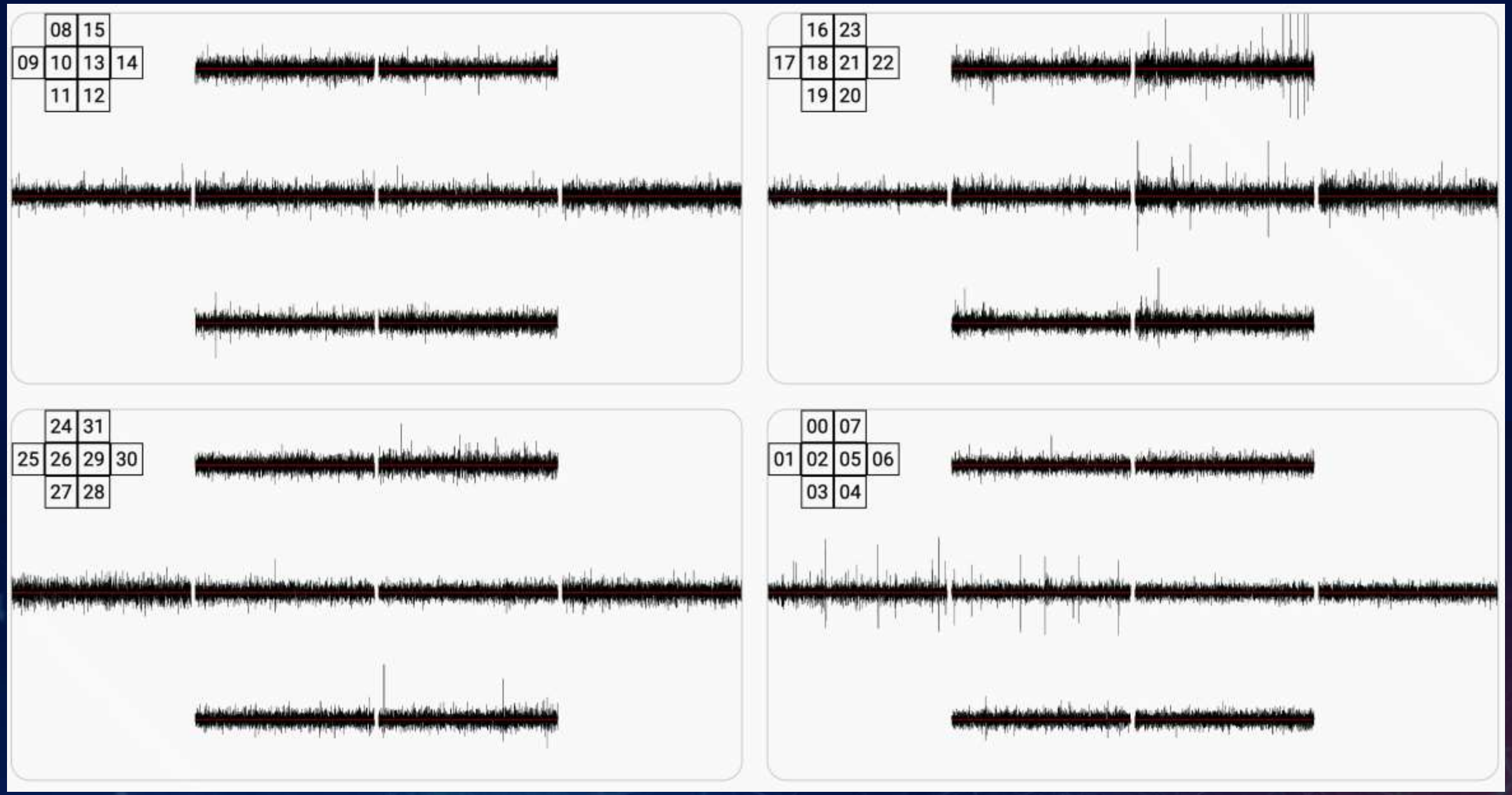
08 15
09 10 13 14
11 12
16 23
17 18 21 22
19 20
24 31
25 26 29 30
27 28
00 07
01 02 05 06
03 04

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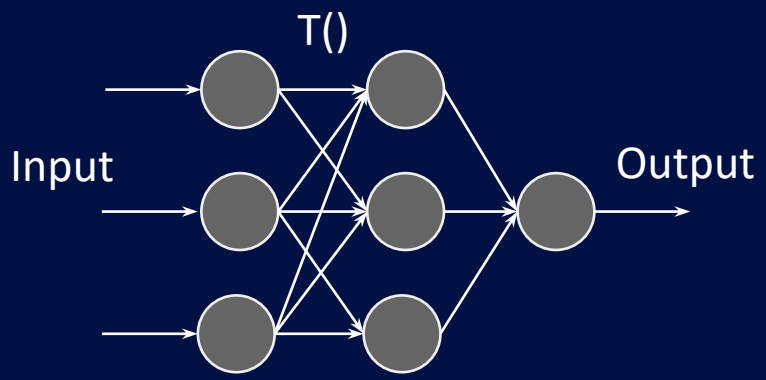
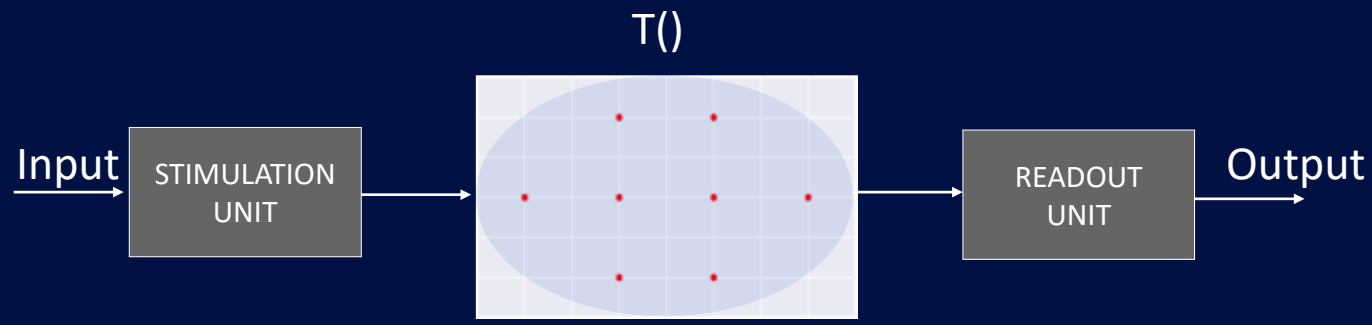
SIMILARITIES BETWEEN ARTIFICIAL AND BIOLOGICAL NEURAL NETWORKS





Output = T(Input, <State>)

Loss = f(Output, Target)

If Loss = 0 then Output = Target

Output = T(Input, <State>)

Loss = f(Output, Target)

If Loss = 0 then Output = Target

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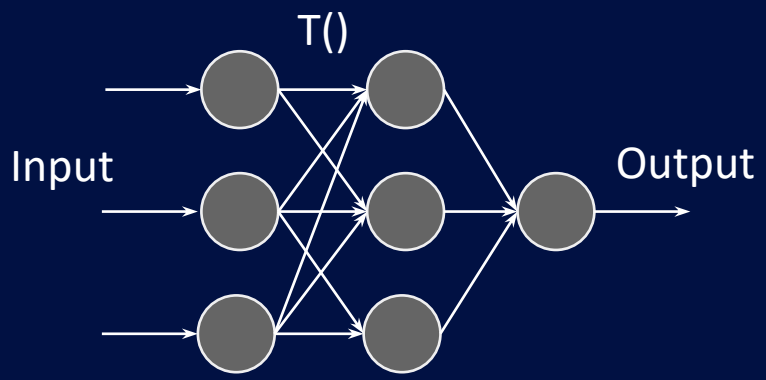
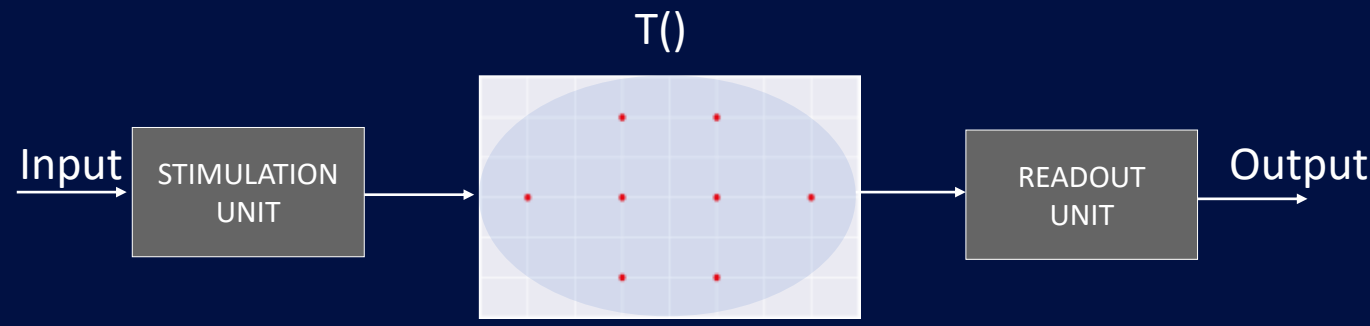
DIFFERENCES BETWEEN ARTIFICIAL AND BIOLOGICAL NEURAL NETWORKS





We know T()

We know <State> = $\{W_{jk}^{l}\}$

We can compute symbolically $\frac{\partial f}{\partial W_{jk}^{l}}$

Simple gradient descent:

$$\Delta W_{jk}^{l} = \alpha \frac{df}{dW_{jk}^{l}}$$

We do not know T()

We do not know <State>

We know that T() and <State> are changing over time

… ☺

How to update state in order to minimize Loss?

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TRAINING IN BIOLOGICAL NEURAL NETWORKS

Reward/punish the network

Stochastic optimisation by spatio-temporal stimulations

LONG TERM POTENTIATION

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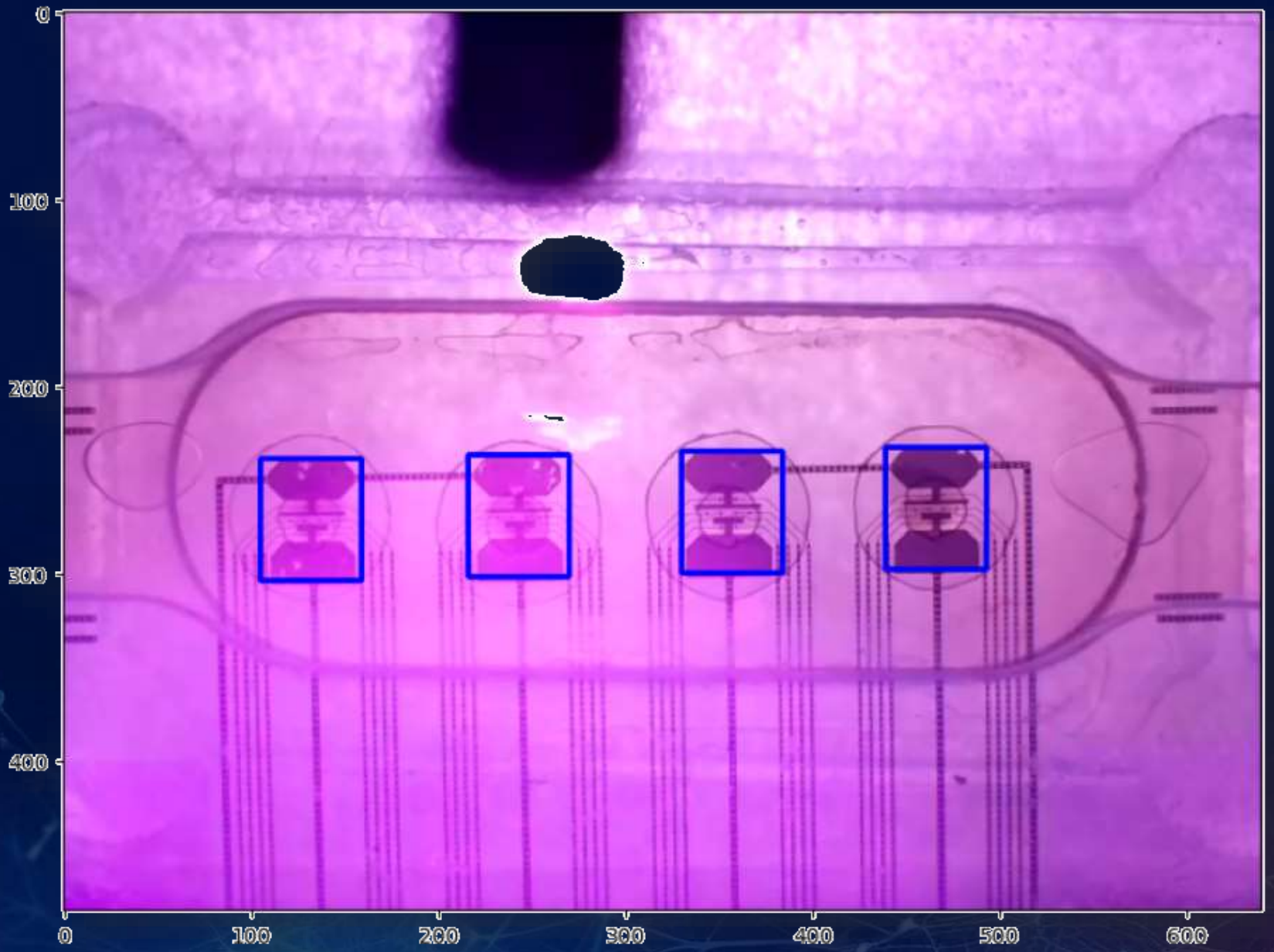

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WHAT IS THE STATUS NOW?

- First results of neuroplasticity
- Over 100 days of organoid lifetime
- Operational 24/7 fluidics and monitoring neuroplatform

OPEN **INNOVATION**: FINALSPARK NEUROPLATFORM

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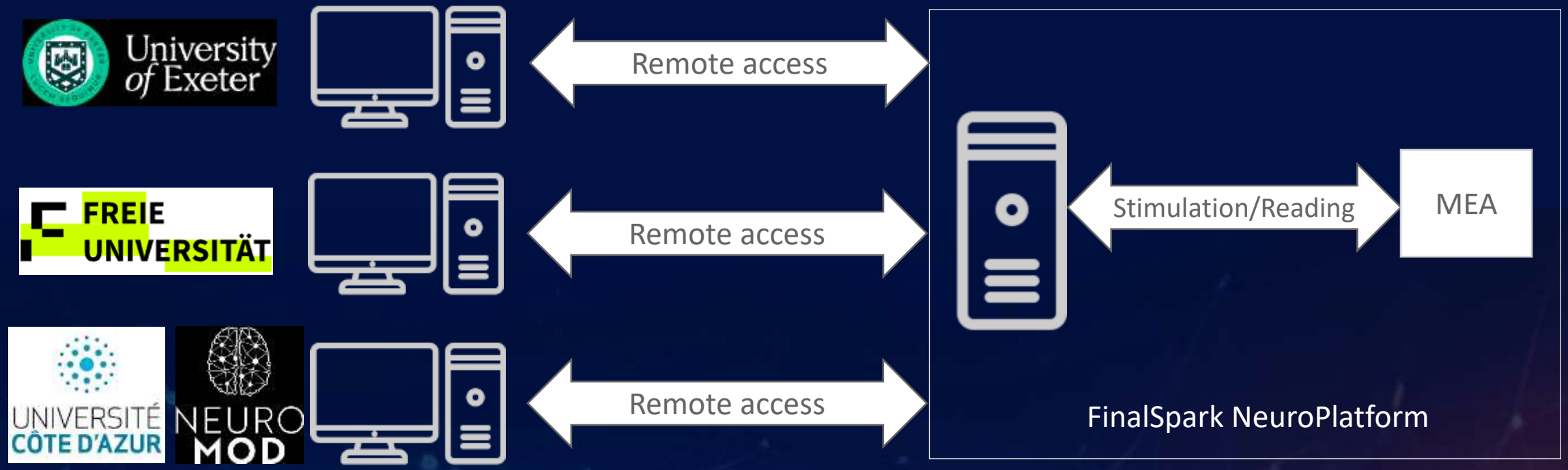
OPEN INNOVATION

- 50 candidate research groups
- 8 selected
- 3 started

OPEN INNOVATION



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```python
for _ in range(4*60):

    # Stimulation
    for i in range(8):
        trigger.send(readingTriggers[i])
        time.sleep(0.01) # 10ms
    # Read number of spikes
    nb_spikes = read(trigger, intan, listeningTrigger)
    nb_spikes_ns = np.sum(nb_spikes[all_electrodes])

    diff_spikes = nb_spikes_ns-nb_spikes_ns_history[-1]
    nb_spikes_ns_history.append(nb_spikes_ns)

    clear_output(True)
    print(f'# Spikes: {nb_spikes_ns}')

    if diff_spikes > 0: # Increase of spike activity
        triggerUV.send(100) # trigger UV for 100ms
        time.sleep(0.1)

        # Increase speed of the pump to 5 rpm
        peristaltic.rpm(5, PeristalticDirection.CounterClockWise)

    time.sleep(60) # wait 1min
    peristaltic.rpm(1, PeristalticDirection.CounterClockWise) # set speed 1 rpm
```

BIOCOMPUTING
IT'S BECOMING HOT

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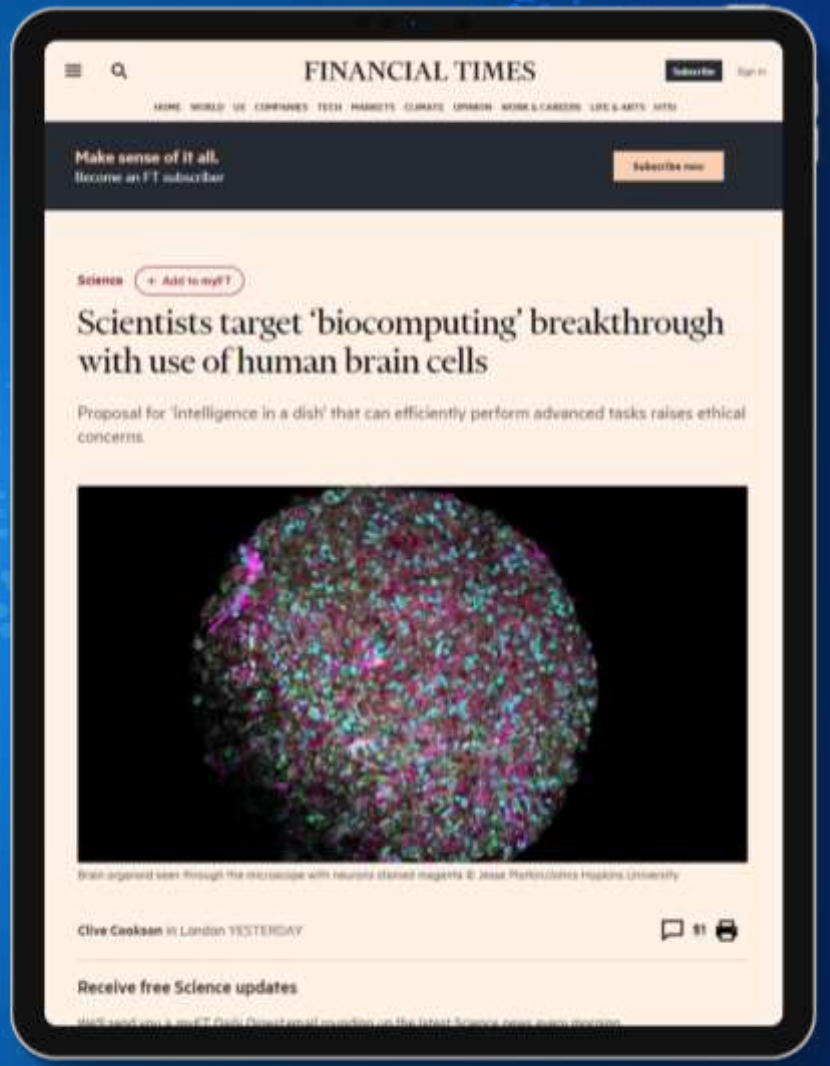
Frontiers in Artificial Intelligence > Organoid Intelligence

Organoid Intelligence

Explores the disruptive technological revolution of AI

Bridges the gap between neuroscience and Artificial Intelligence (AI) technologies



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CONTACT

Get in touch with us:

Phone: +41 21 948 6464

Email: fred.jordan@finalspark.com

Rue du clos 12
1800 Vevey
Switzerland

Web: www.finalspark.com

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