tinyML® Talks

Enabling Ultra-low Power Machine Learning at the Edge

"Biosensing at the edge of the Cloud"

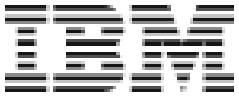
Martin Peacock – Director and CSO, Zimmer and Peacock

August 22, 2023

www.tinyML.org

TINY ML TALKS webcast

Thank you, **tinyML Strategic Partners**,
for committing to take tinyML to the next Level, together



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Executive Strategic Partners

Qualcomm
AI research

Advancing AI research to make efficient AI ubiquitous

Power efficiency

Model design, compression, quantization, algorithms, efficient hardware, software tool

Personalization

Continuous learning, contextual, always-on, privacy-preserved, distributed learning

Efficient learning

Robust learning through minimal data, unsupervised learning, on-device learning

A platform to scale AI across the industry

Perception

Object detection, speech recognition, contextual fusion

Reasoning

Scene understanding, language understanding, behavior prediction

Action

Reinforcement learning for decision making

Edge cloud

Cloud

IoT/IIoT

Automotive

Mobile

Qualcomm AI Research is an initiative of Qualcomm Technologies, Inc.

Accelerate Your Edge Compute

SYNTIANT

Making Edge AI A Reality

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Platinum Strategic Partners

AITRIOS

DEPLOY VISION AI AT THE EDGE AT SCALE

SONY

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Build the
Future of tinyML
on arm

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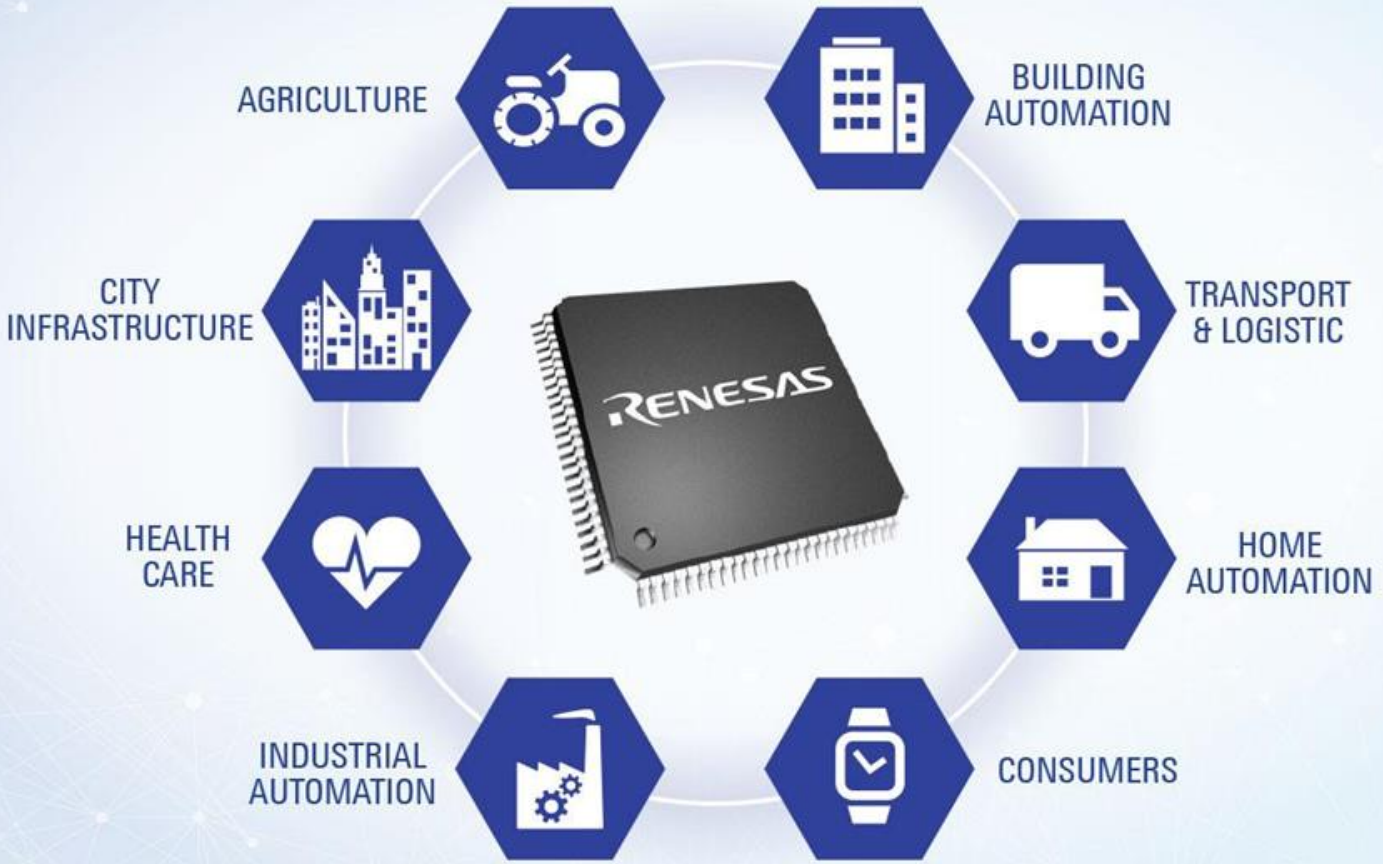

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life.augmented

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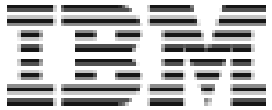
Silver Strategic Partners



Join Growing tinyML Communities:

16.2k members in
49 Groups in 41 Countries

tinyML - Enabling ultra-low Power ML at the Edge

https://www.meetup.com/tinyML-Enabling-ultra-low-Power-ML-at-the-Edge/

4k members
&
12.7k followers

The tinyML Community

https://www.linkedin.com/groups/13694488/

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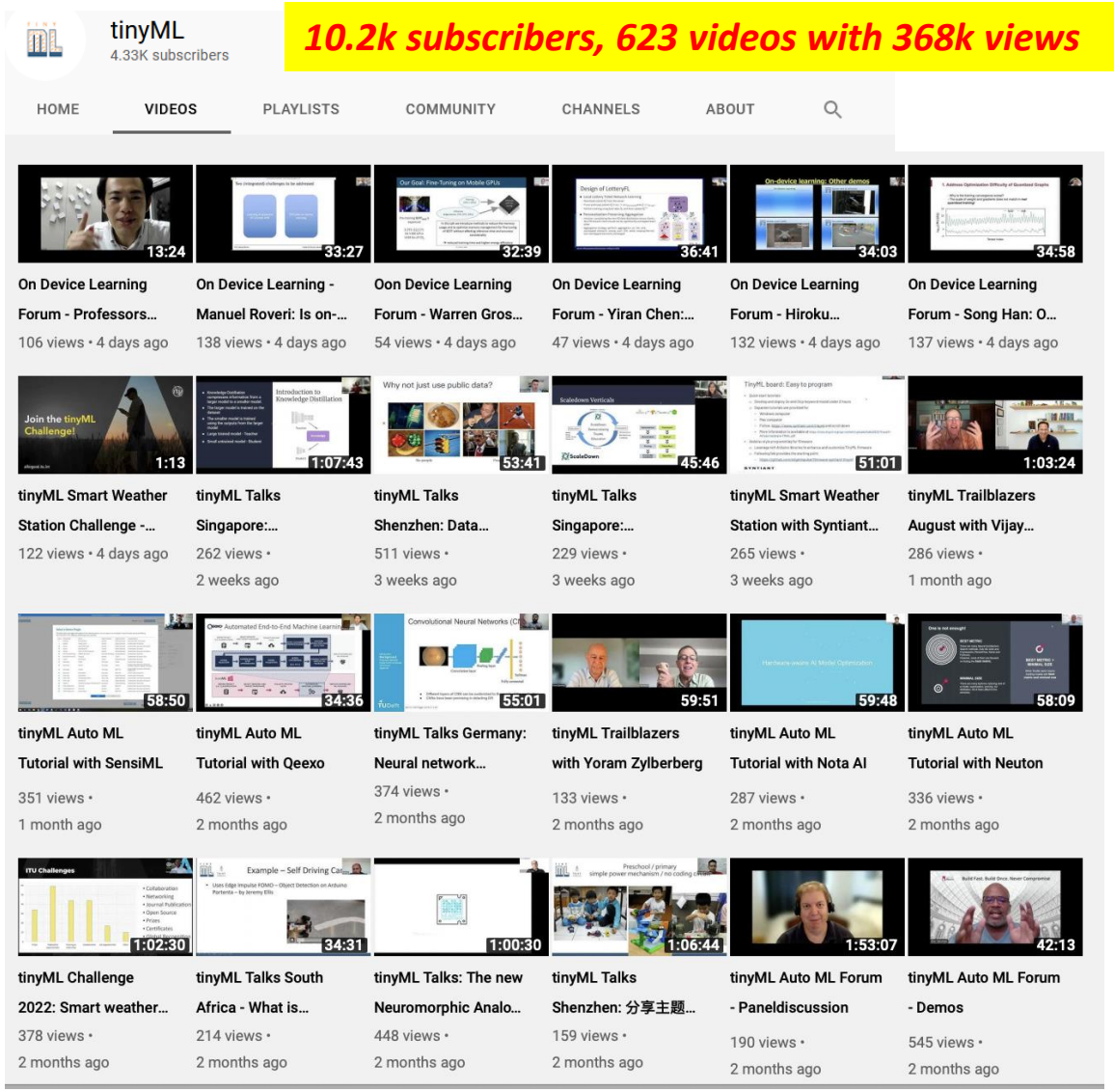
YouTube



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(including this video)

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TINY ML FOUNDATION

Call for Presentations and Posters – Deadline August 7
https://www.tinyml.org/event/asia-2023/

WEVOLVER

https://www.wevolver.com/article/2023-edge-ai-technology-report

TINY ML FOUNDATION

2023 Edge AI Technology Report

The guide to understanding the state of the art in hardware & software in Edge AI.

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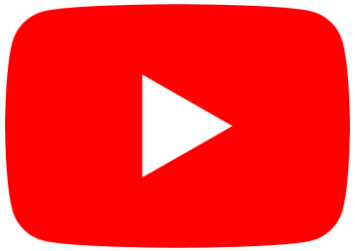
Reminders

Slides & Videos will be posted tomorrow

tinyml.org/forums



youtube.com/tinyml

Please use the Q&A window for your questions

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Martin Peacock

Dr Martin Peacock is an industrial bioelectrochemist with over twenty years of biosensor experience, having had industrial roles from Abbott Diabetes to GSK, and solving technical challenges from continuous glucose monitoring to RNA analysis. In recent years Martin has set-up biosensor focused companies across the globe from Silicon Valley California to Oslo Norway.

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Today

ABSTRACT

One of the last frontiers of the Internet-of-Things and TinyML is collecting and interpreting chemical, biochemical and biological data. There are multitudes of solutions for knowing the condition of a system through the capture of temperature, humidity, position, images etc, but knowing the chemical and biological condition of a system is still the most unexplored domain.

In this talk ZP discusses biosensors for a smart bio-edge including sensors for: viruses, nitrate, purines, oxidative status, capsaicin, and purines; applications covered in this talk includes Clean Water, Food Quality and Health.

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Call to action

All the easy stuff is done, time for biology

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Today

- Quick introduction to ZP and myself
- Why does ZP exist
  - IoT, TinyML and the technology/application gaps
- Wearables – Embedded and Transdermal
- IVD (Lab on a chip, Rapid Diagnostic Testing, PoCD, Spot testing)
- Applications:
  - Food Quality , Clean Water and Health

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Quick resume

Scan to connect with me on LinkedIn

- Martin Peacock
- First degree chemistry
- Second degree electrochemistry
- Industrial roles:
  - GSK – Medicinal Chemist
  - Abbot Diabetes – Electrochemist
- Companies founded in the last 4-years:
  - Zimmer and Peacock Ltd
  - Zimmer and Peacock AS
  - Zimmer and Peacock Inc
  - CeeLab
  - Aliksir

Brief Introduction to ZP

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ZP - Commercial

- Launched - 2014
- ISO13485 – Development and manufacturing of biosensor and IVDs
- Contract developers and manufacturers of electrochemical biosensors
- Norway and UK

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ZP Team

ZP

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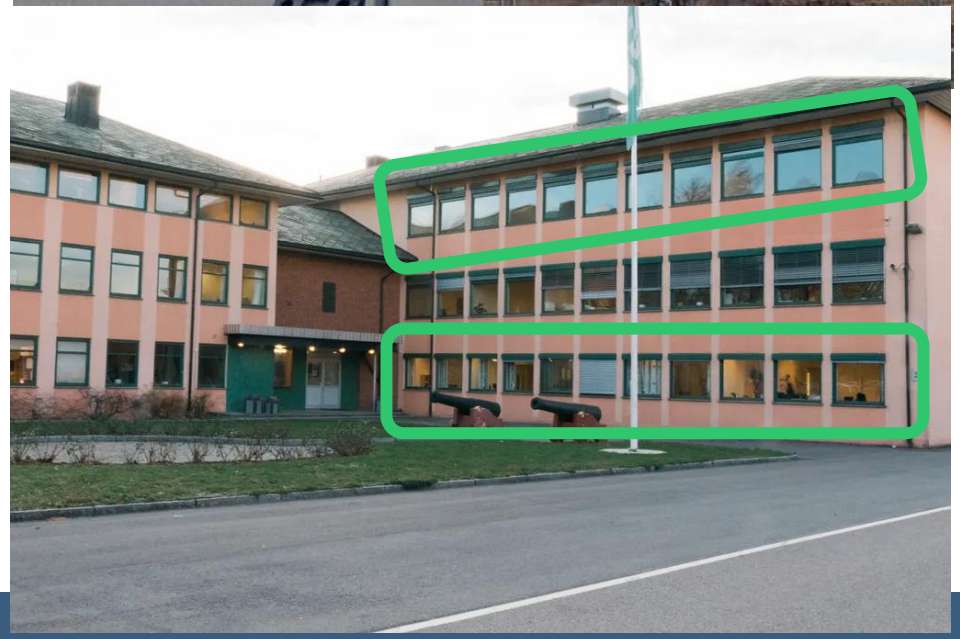
Norway



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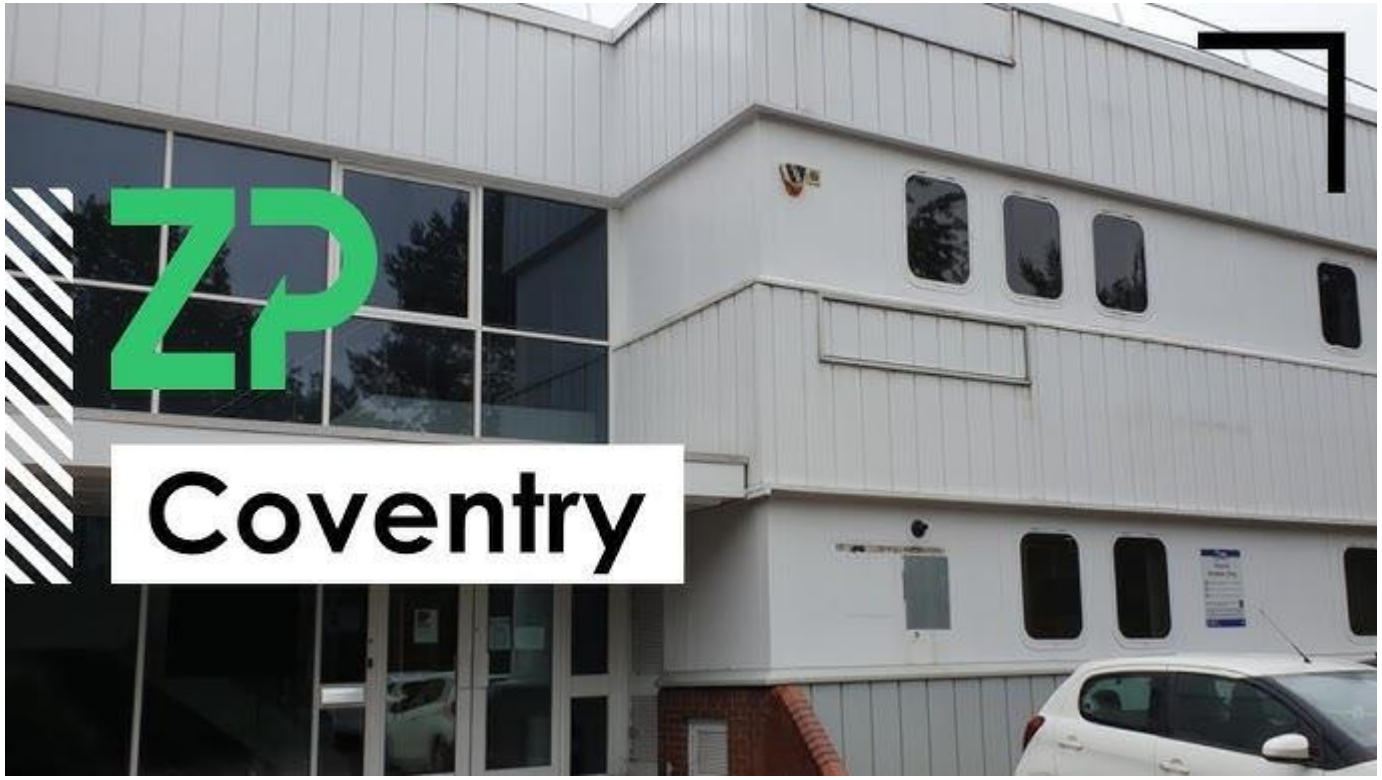
United Kingdom



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Why are we here?

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Why ZP?

MISSING

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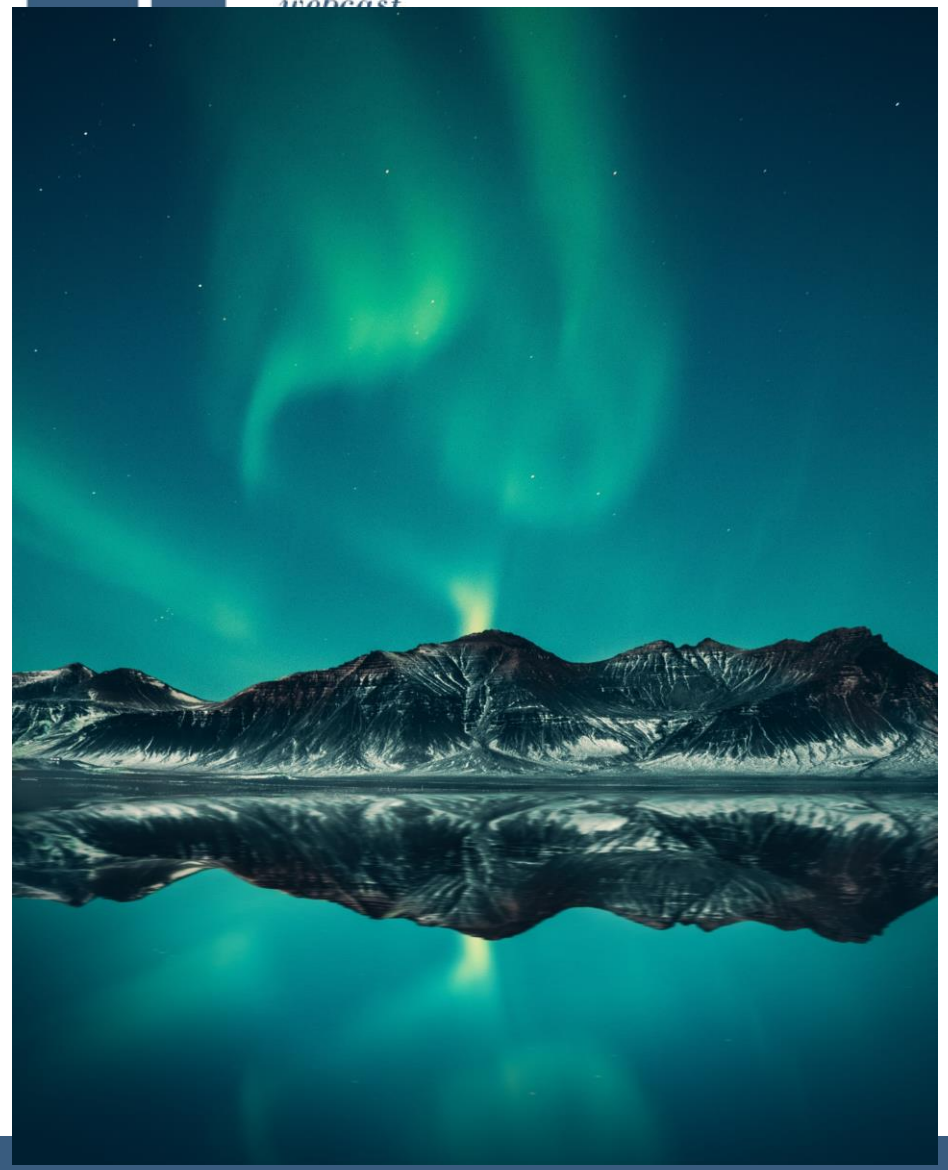

Solid

Liquid ✓

Gas

Sweat

Saliva

Tear film

Urine

Interstitial fluid

Blood

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What makes what we do possible

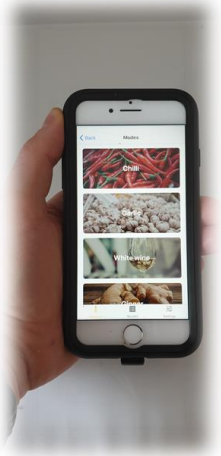
Low Power

Miniaturization

Connectivity

Cloud computing/API

Data Sciences/AI/TinyML



Smart phones

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Trends in biosensing Miniaturization

CLINICAL LAB ANALYSER

TABLE TOP

HAND HELD

PALM SIZE

WEARABLE

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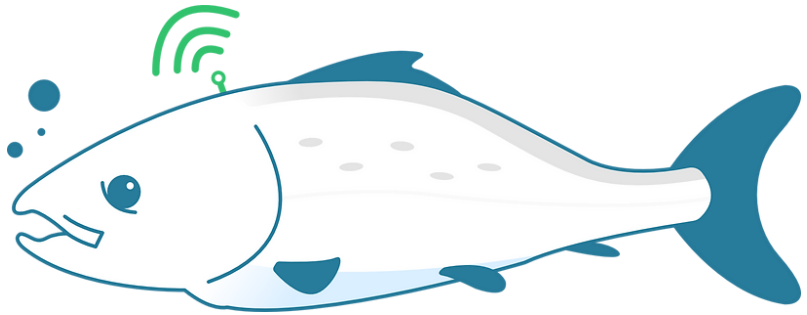
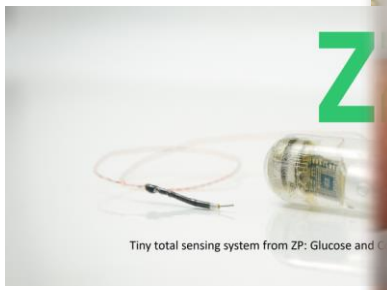
Applications





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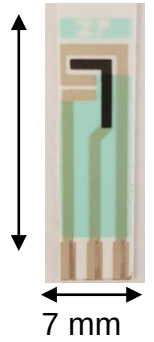
Electrochemical biosensors



- Glu — Glucose Sensors
- O_2 — Oxygen Sensors
- Lac — Lactate Sensors
- H_2O_2 — Hydrogen Peroxide Sensors
- pH — pH Sensors
- Cl^- — Chloride Sensors
- K^+ — Potassium Sensors
- Ca^{2+} — Calcium Sensors
- Alcohol — Alcohol Sensors
- NO_3^- — Nitrate Sensors
- NO — Nitric Oxide Sensors
- NH_4^+ — Ammonium Sensors
- Uric Acid — Uric Acid Sensors
- Na^+ — Sodium Sensors
- HPO_4^{2-} — Phosphate Sensors
- SO_3^{2-} — Sulfite Sensors
- ORP TAS FRAP — REDOX/ TAS/ FRAP
- Ketone — Ketone Sensors
- S/m — Conductivity/Salinity Sensors
- NADH — NADH Sensors
- Purine Sensor
- Fructose Sensors
- Cortisol — Cortisol Sensor
- Skatole Sensor
- Androstenone Sensor
- Troponin — Troponin Sensor
- Galactose Sensor
- Glycerol — Glycerol Sensor
- Malic Acid Sensor

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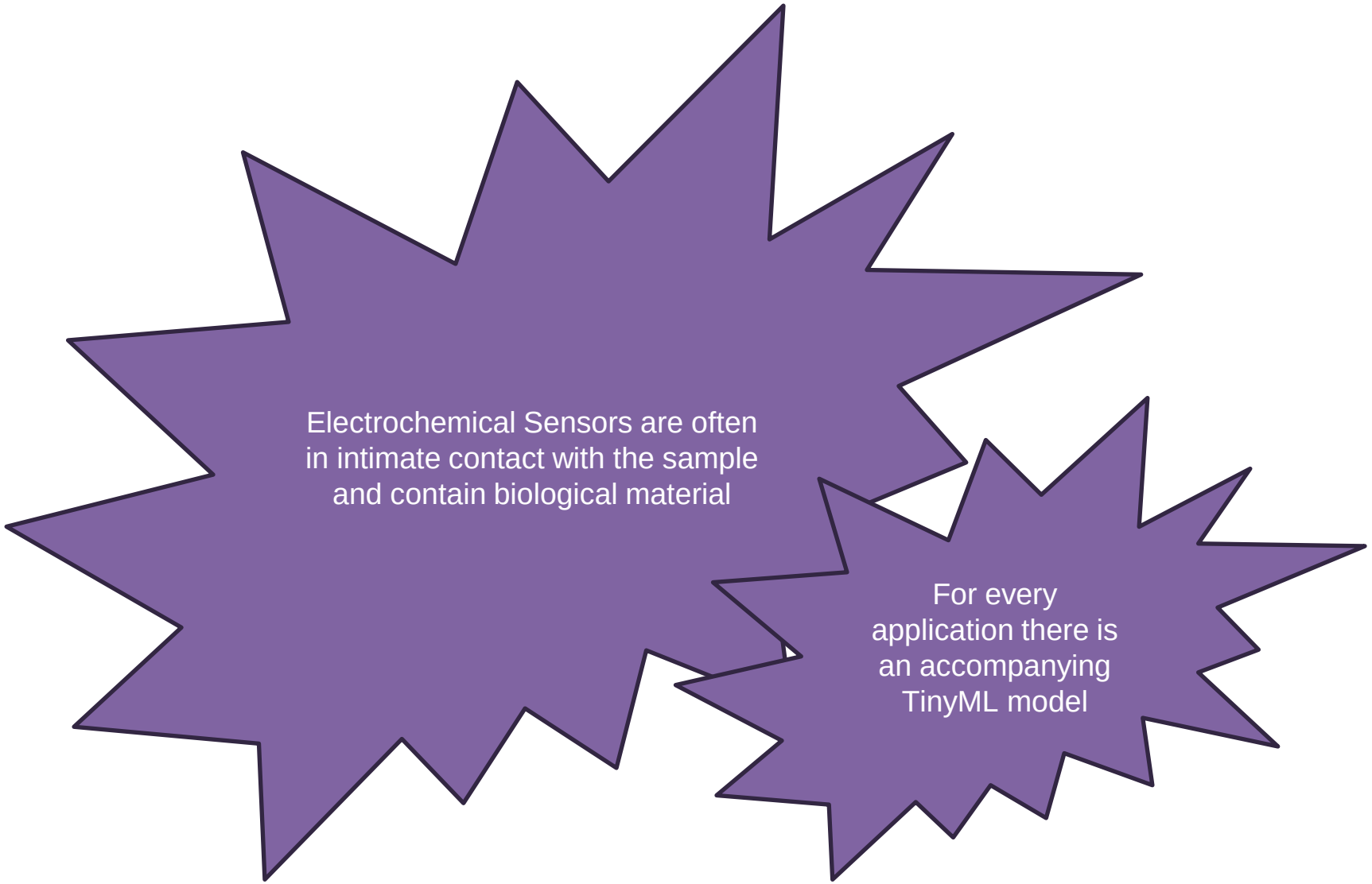

Low cost to manufacture and scalable

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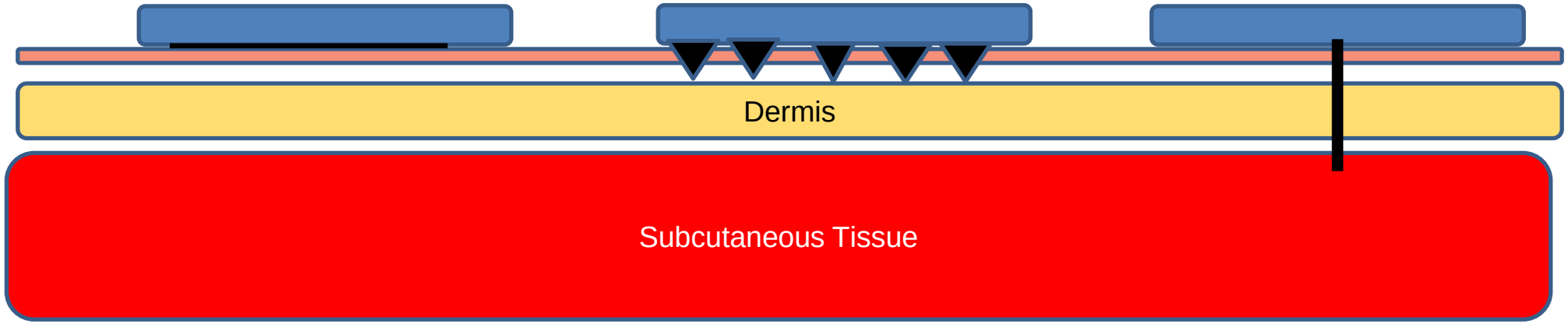
Conf ions

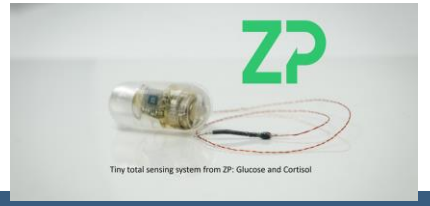
Non-invasive

Microneedles

Wire/filament

Epidermis





Implanted

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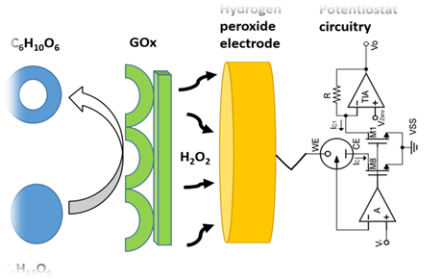
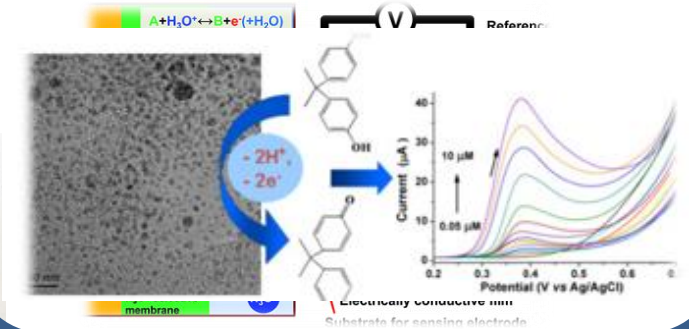
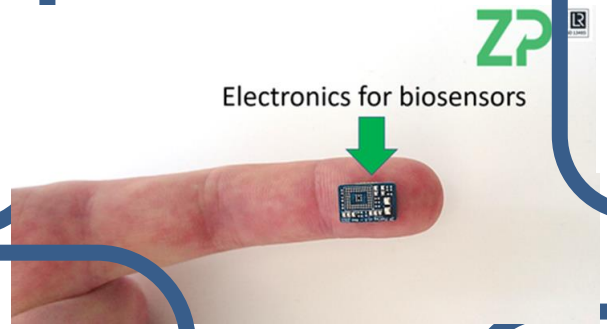
Electroanalytical techniques

Amperometry

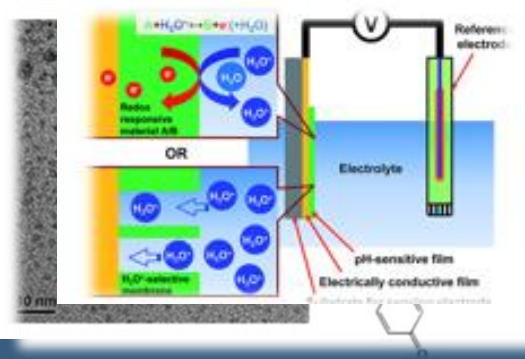


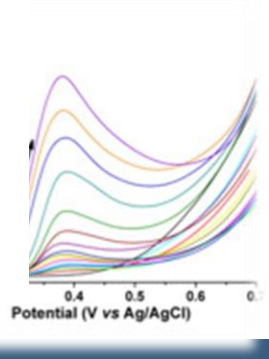
Voltammetry



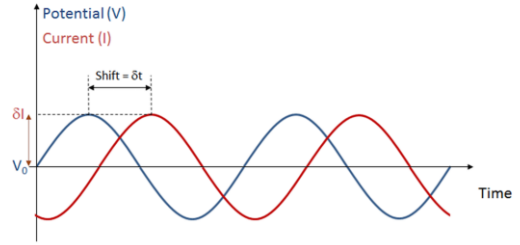


Potentiometry

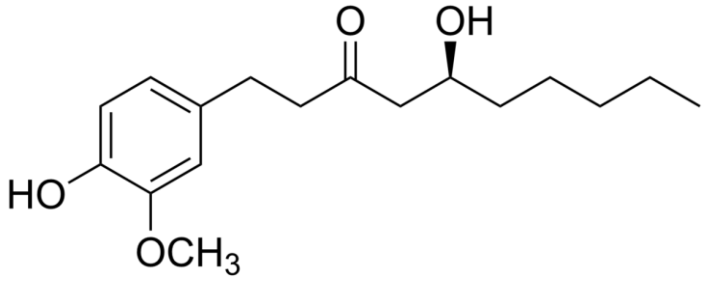


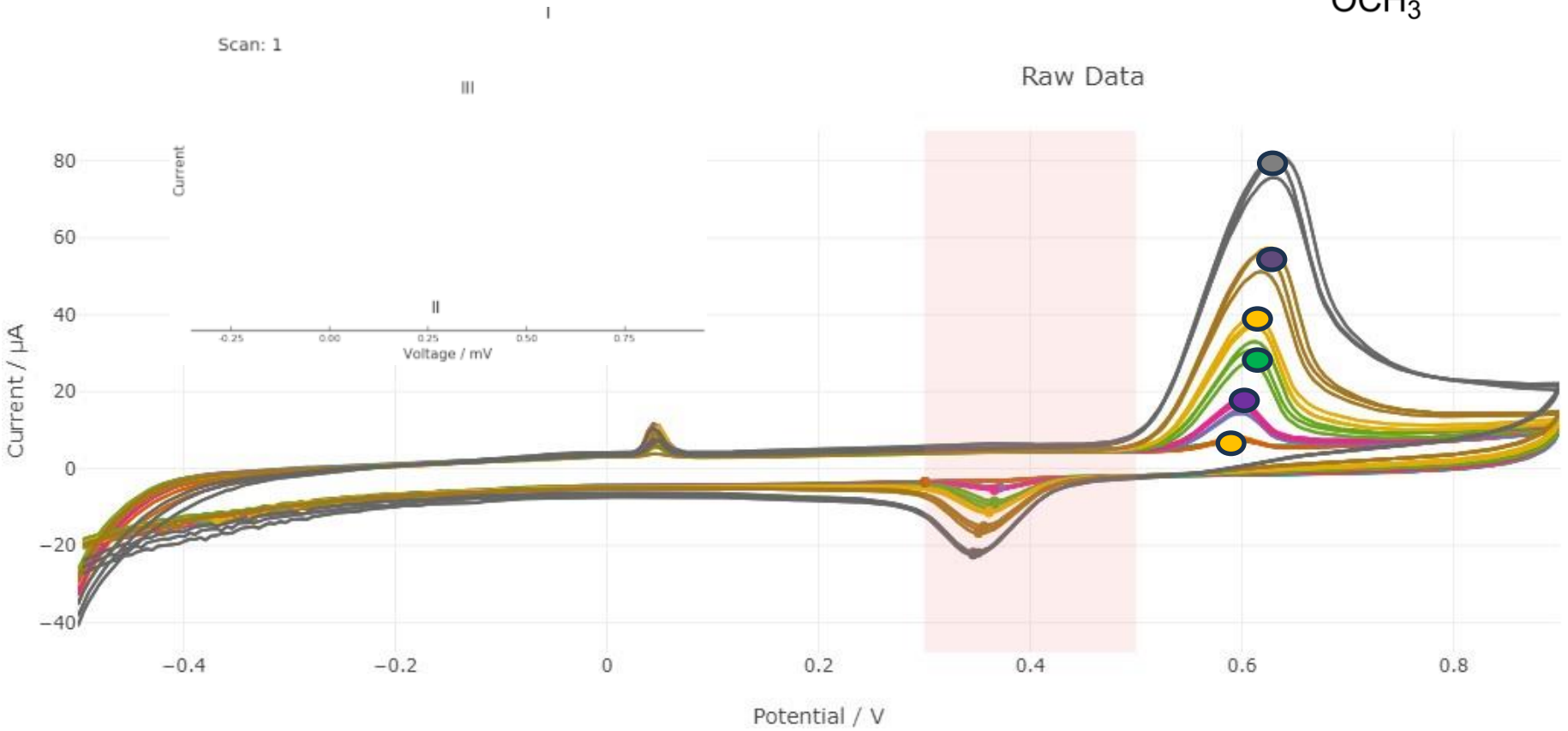


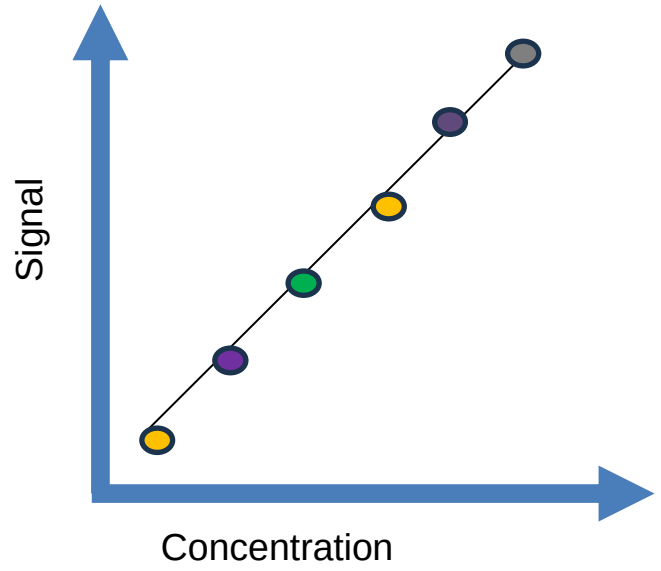
Impedance Spectroscopy



Voltammetry







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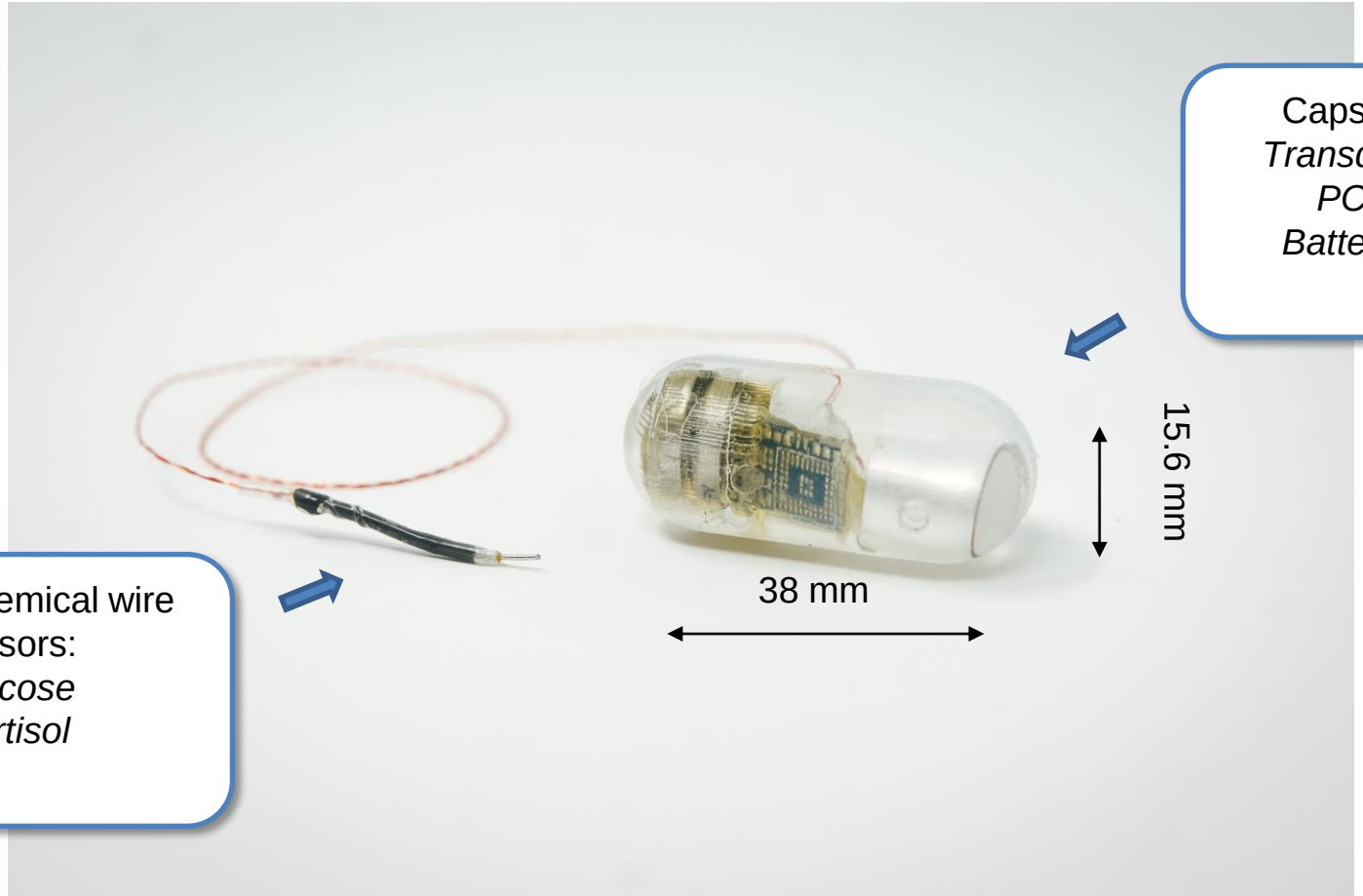
Continuous Measurements

- In-vivo Embedded
- Ex-vivo Wearable
- In-situ soil

Telometry unit with sensors



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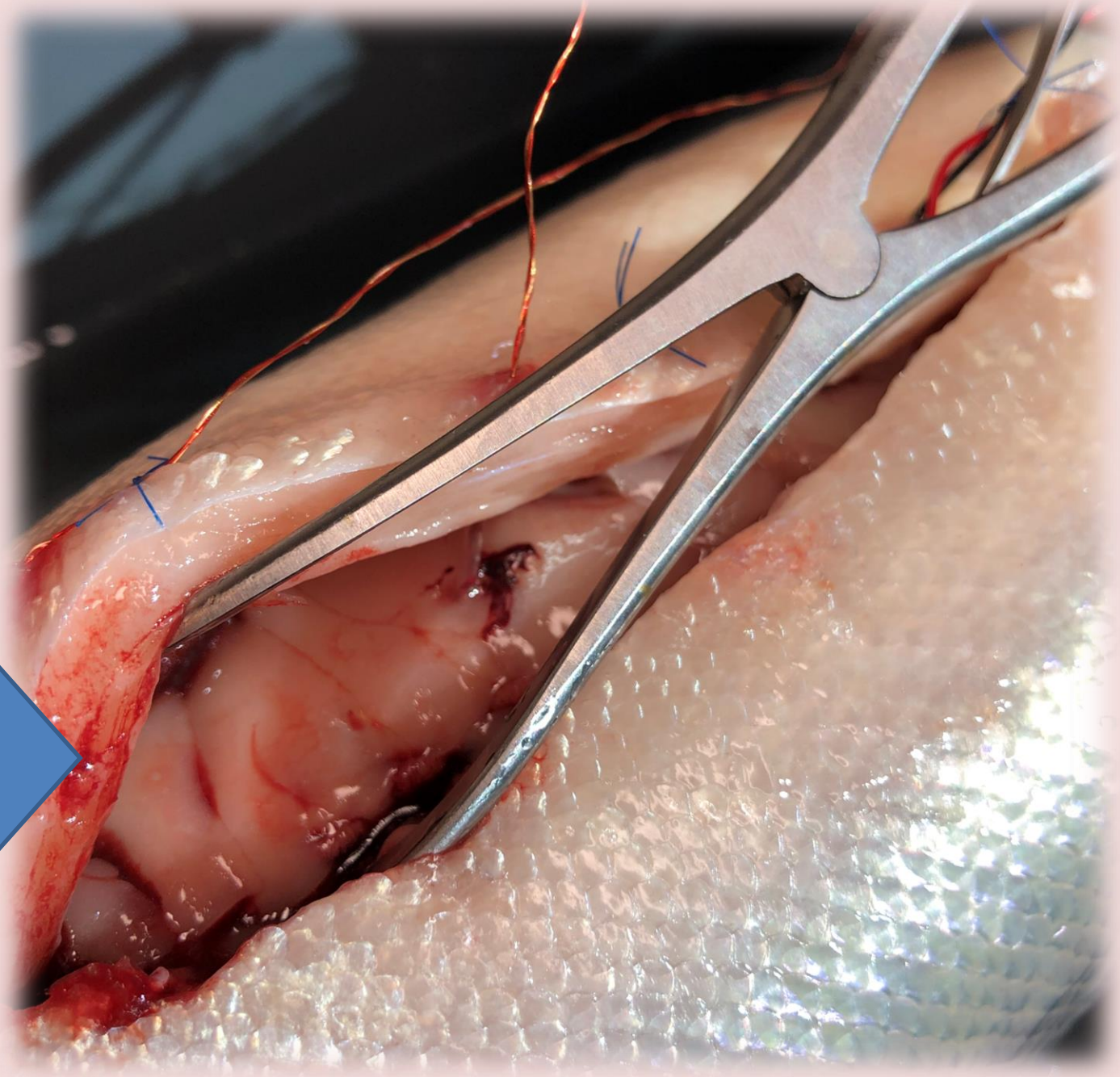

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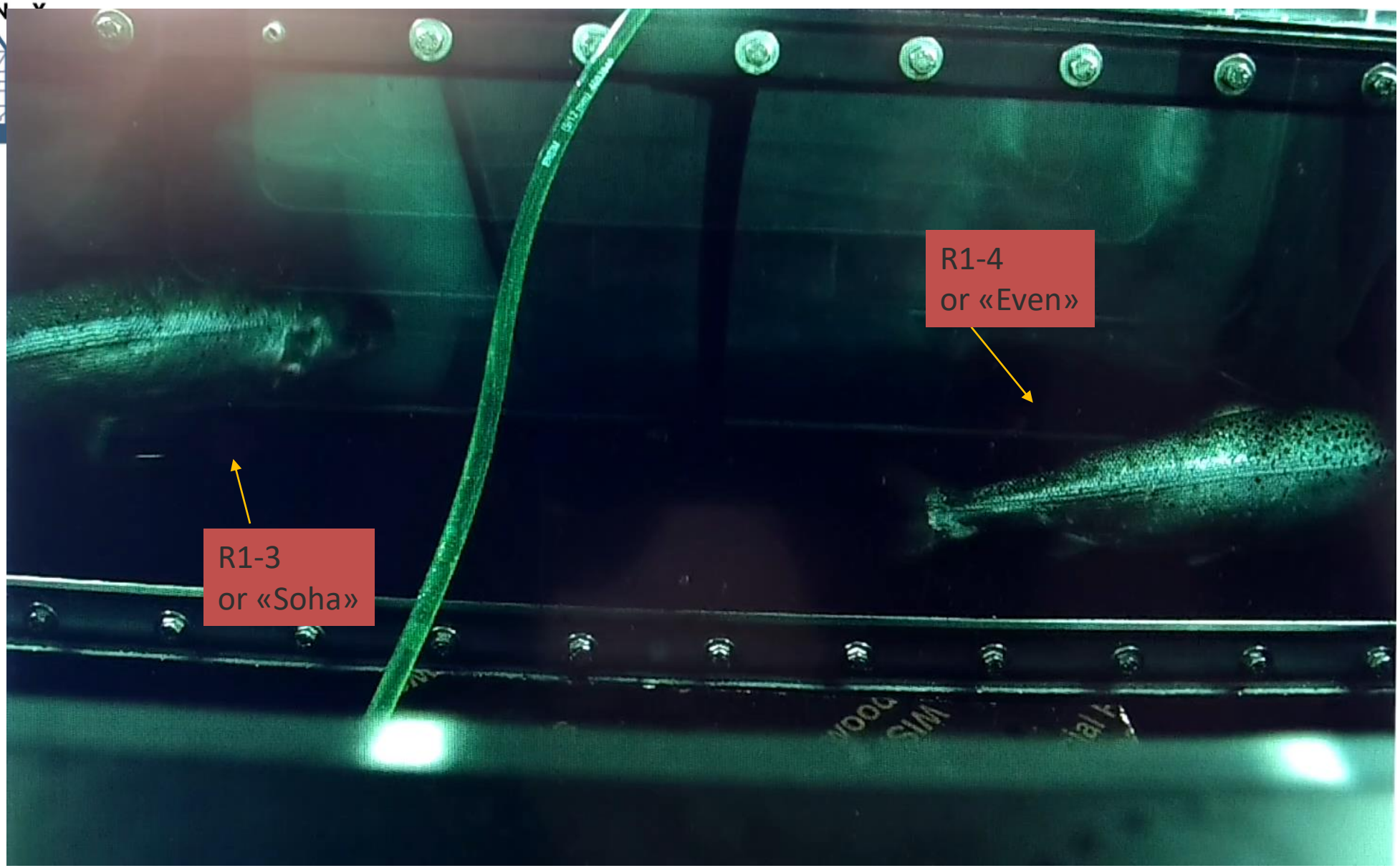
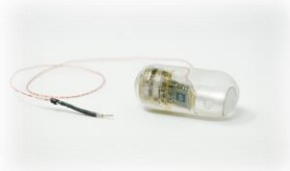

R1-4
or «Even»
R1-3
or «Soha»



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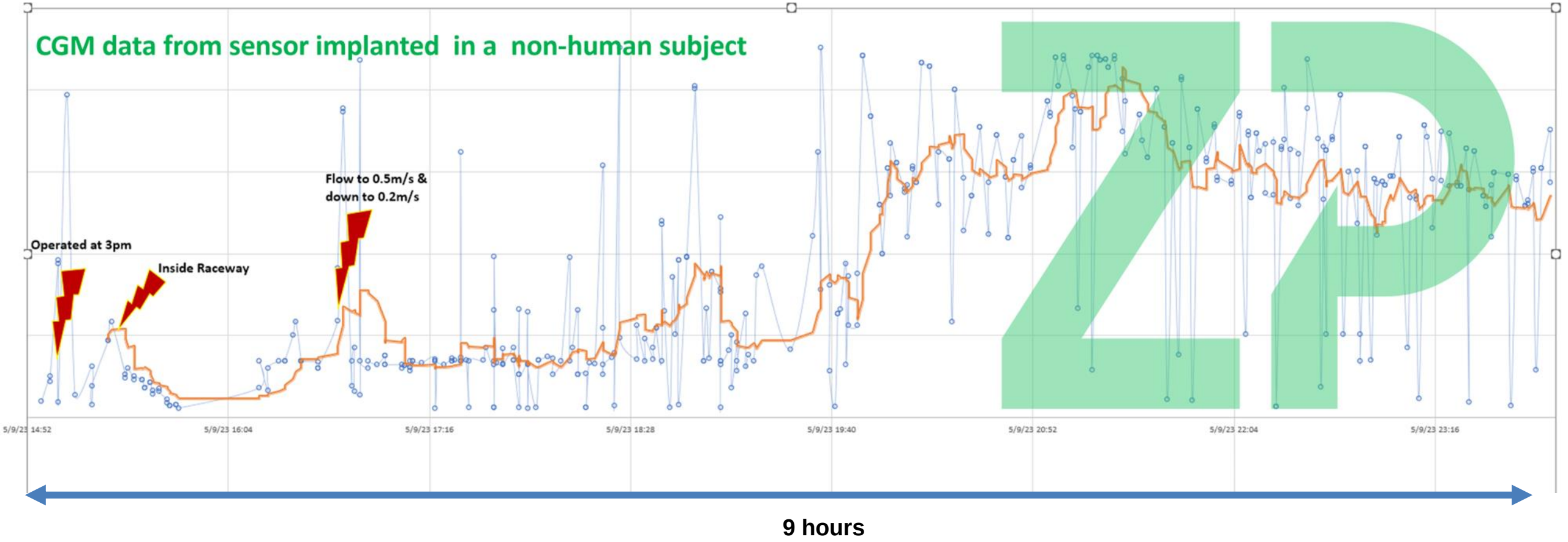
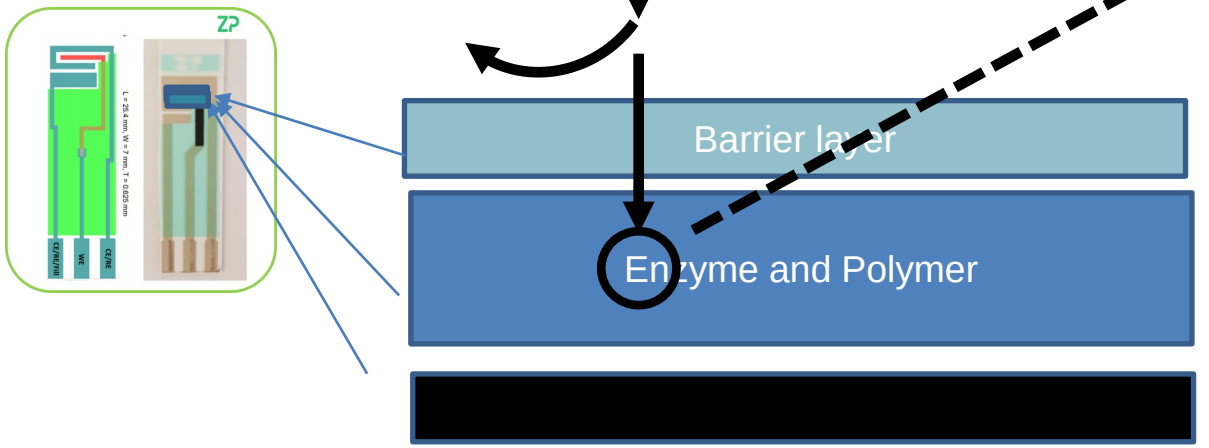
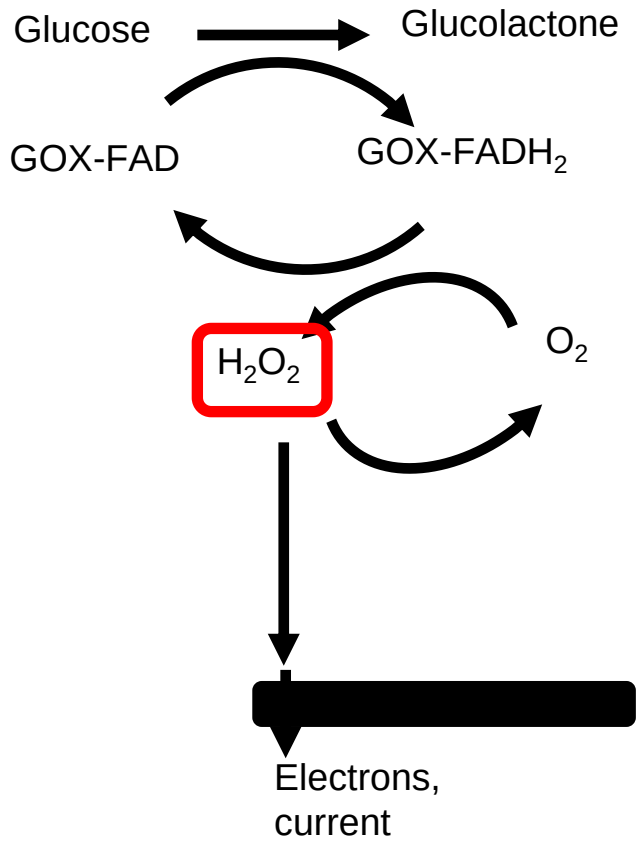


Glucose Sensor – Generation One





V = 650 mV
vs. Ag/AgCl

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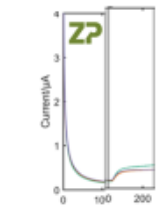
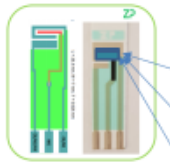
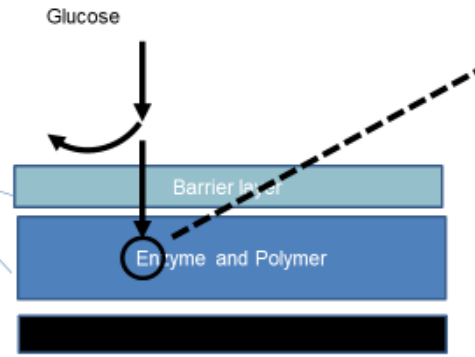
ZP

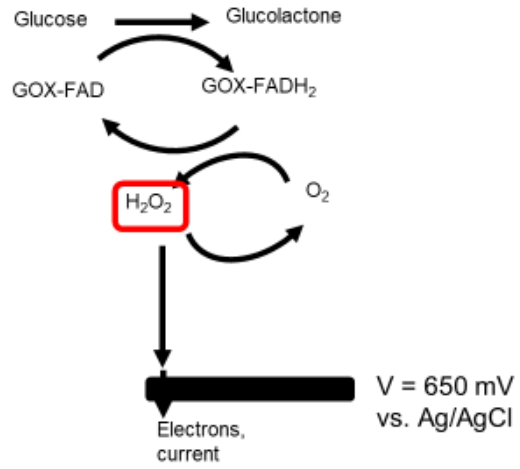
CGM Smartwatch

Glucose Sensor – Generation One









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MEDICAL SMARTWATCH

CONSUMABLE PATCH WITH MICROPOINTS

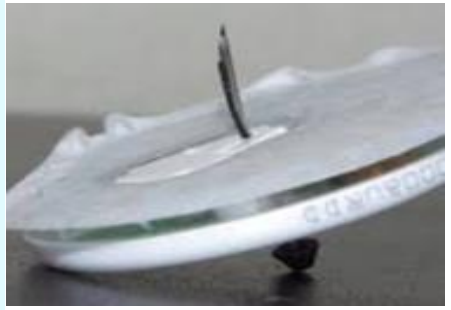
•CGM[1]: A FAST GROWING $14B[2] MARKET, WHERE T2D[1] IS GROWING

BGM[1]

96%

-3%[4]

CGM



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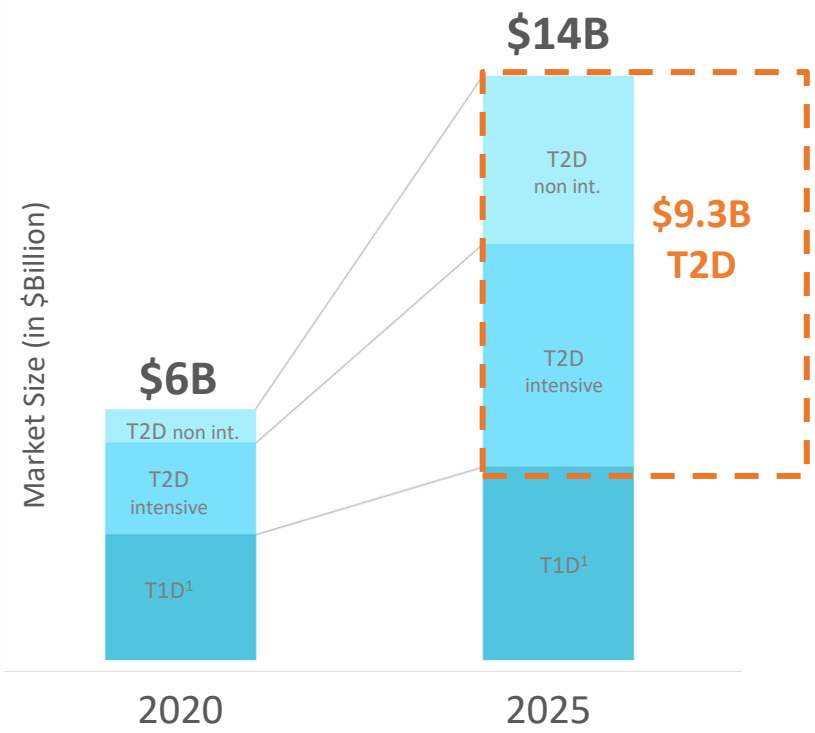
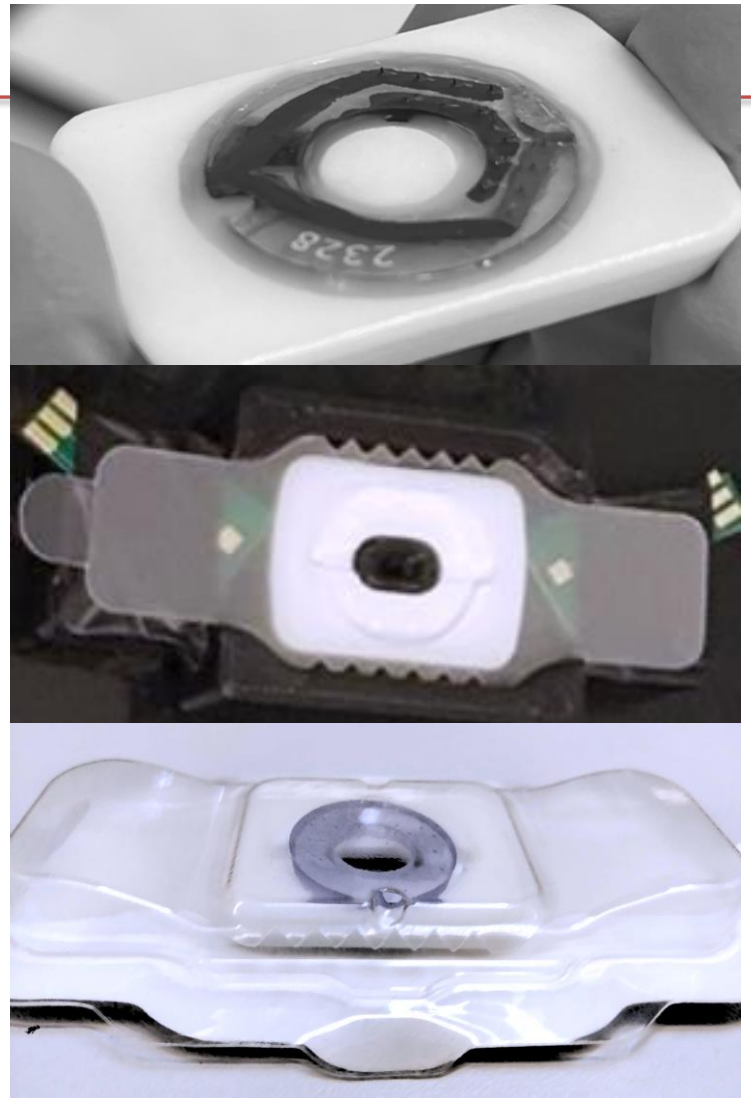
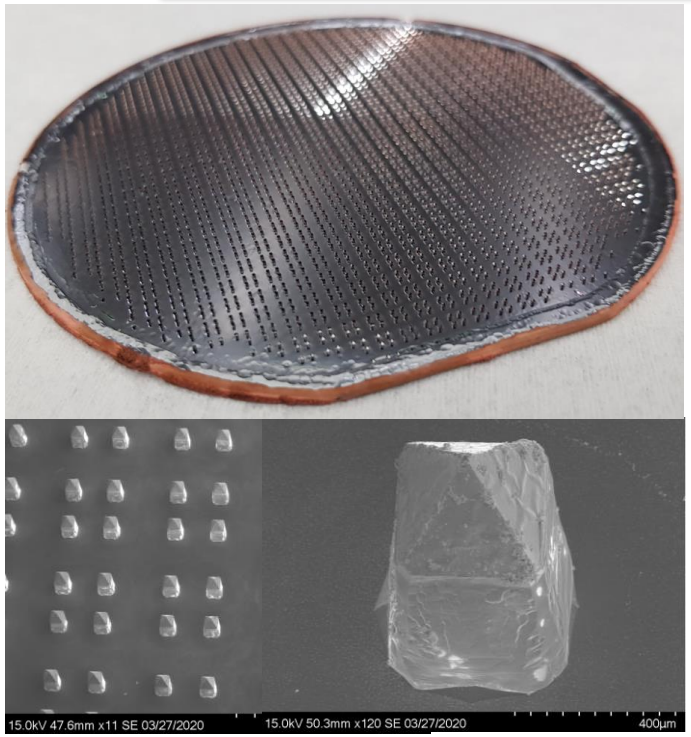
+60%[5]

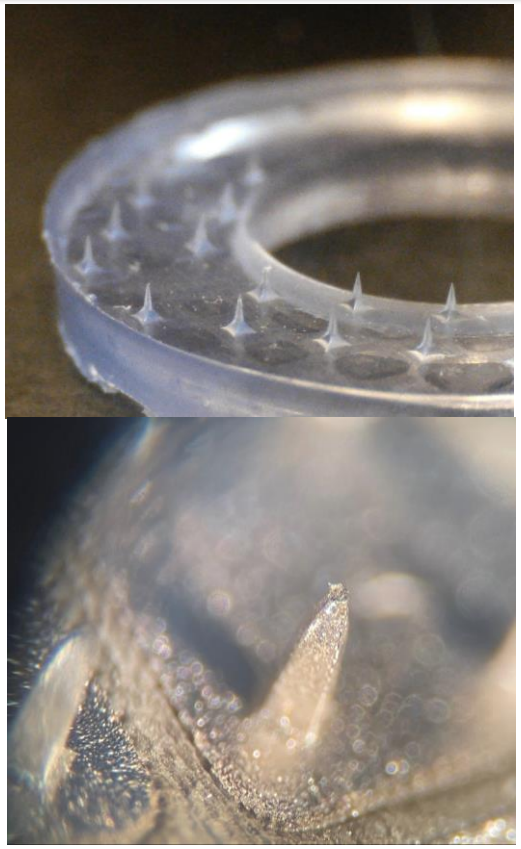




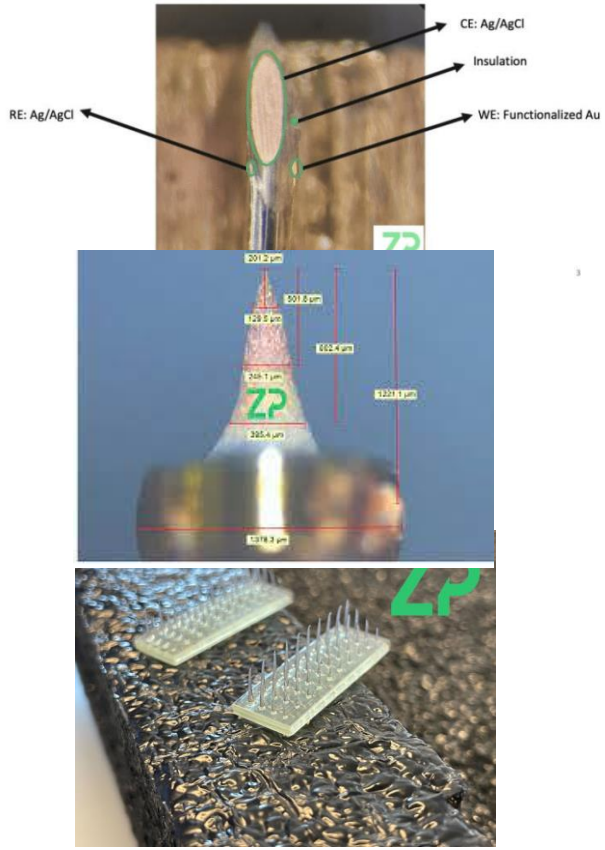
Microneedle development



MEMs fabrication

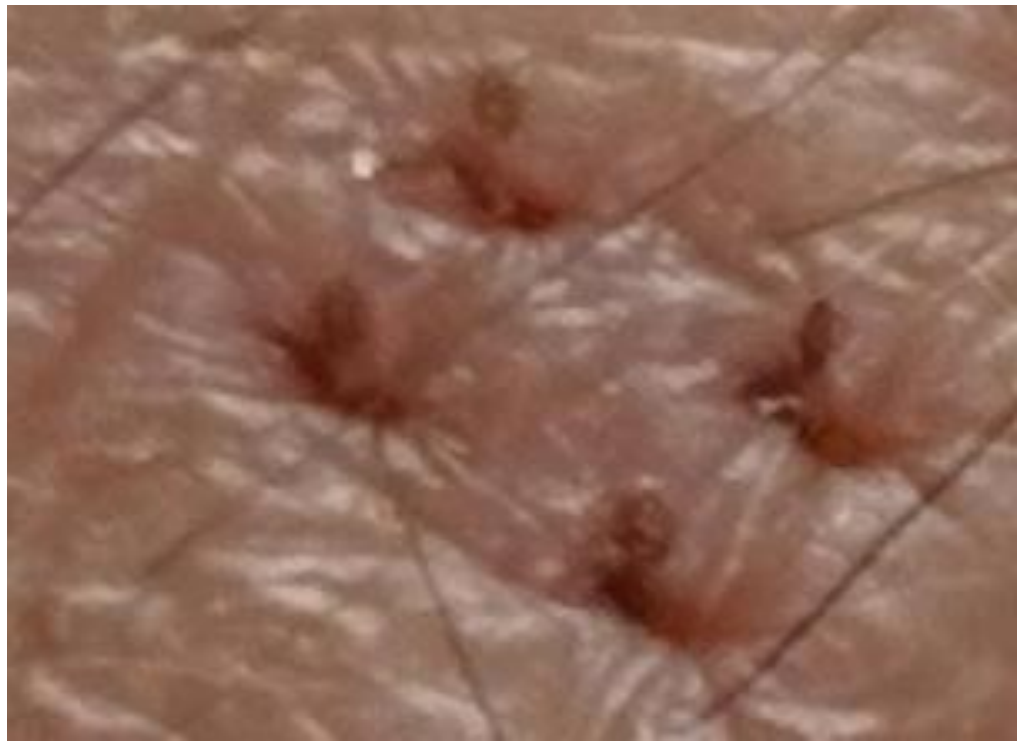


Inject molding



Other sensor fabrications

•SENSOR: EXCELLENT IRRITATION, IN VITRO AND IN VIVO TESTS



1) Mean Absolute Relative Difference, most common metric used to assess the performance of CGM systems

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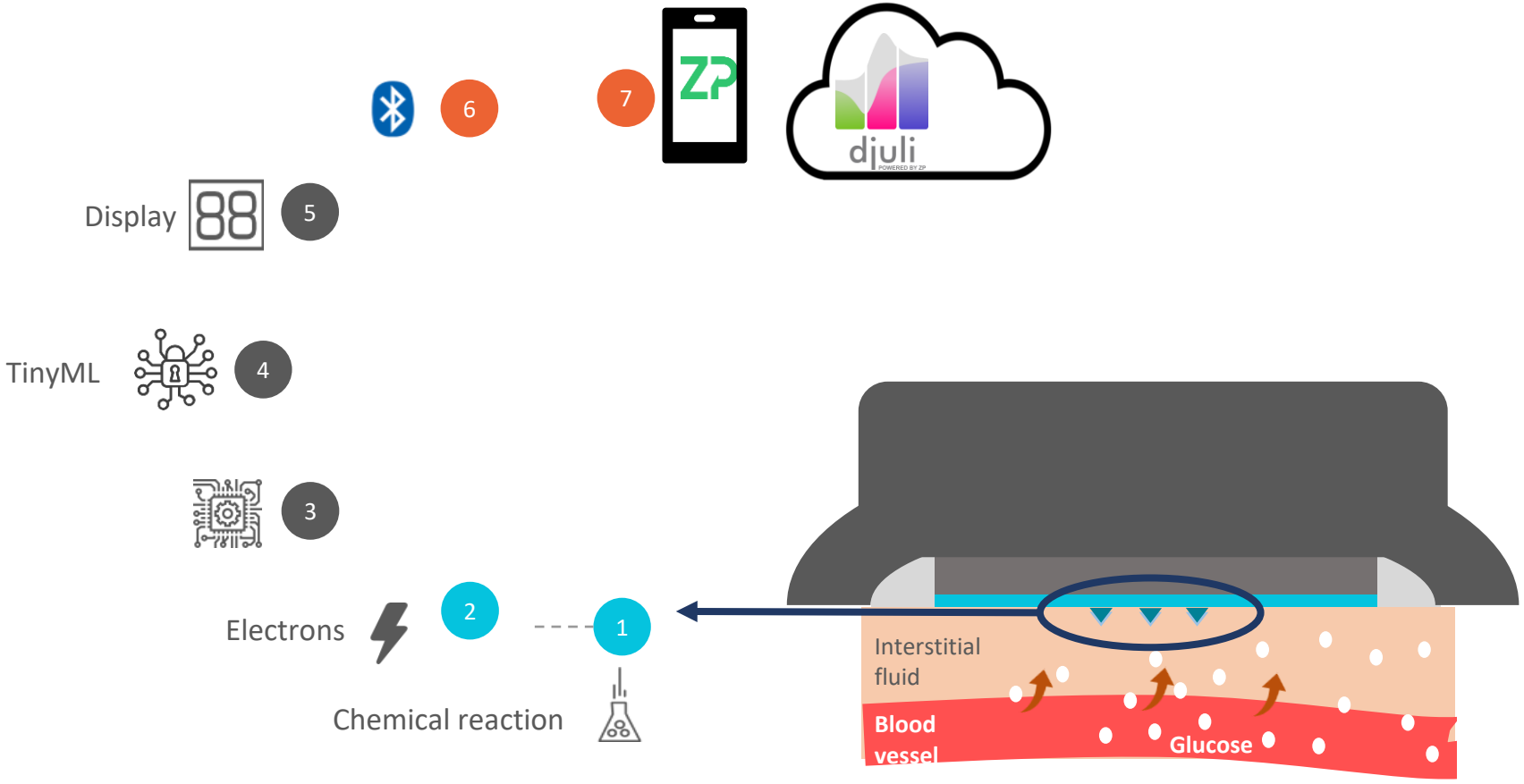

Architecture Protected by 36 Patents

1) For Upper ISF (micro needles) vs fat ISF (single needle solutions): no lagtime in upper ISF, higher glucose concentration = easier to measure - Federico Ribet & Göran Stemme & Niclas Roxhed, Biomedical Microdevices, 2018

Some statistics on nitrate

- 1.2 % of global CO_2 production is from nitrate production
- 1.0 % of global energy production goes into nitrate
- 67 % of nitrates are wasted
- Local pollution: blue baby syndrome, eutrophication, acidification of soil

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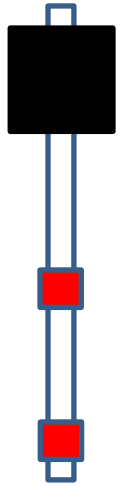
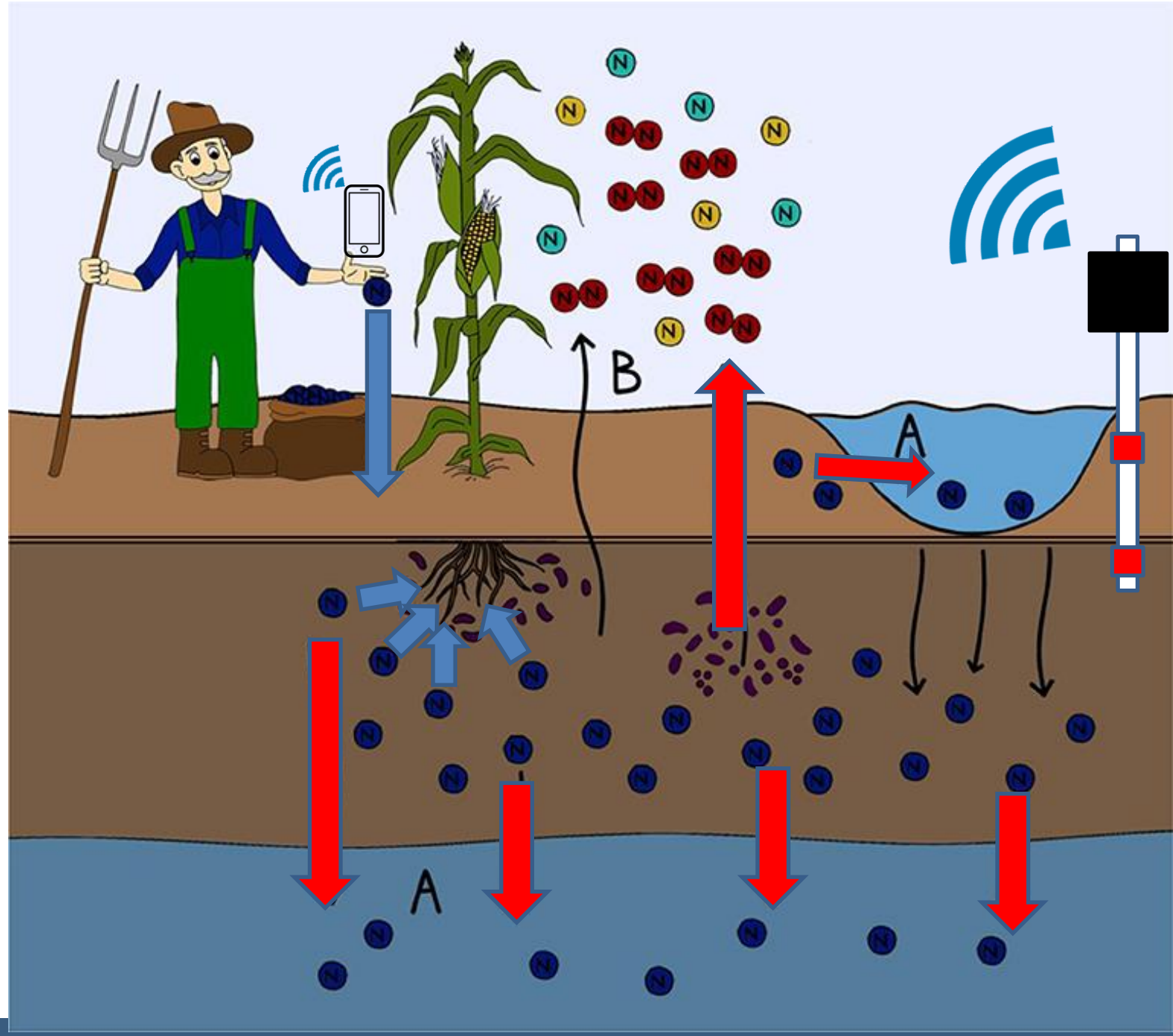
The Problem

The solution





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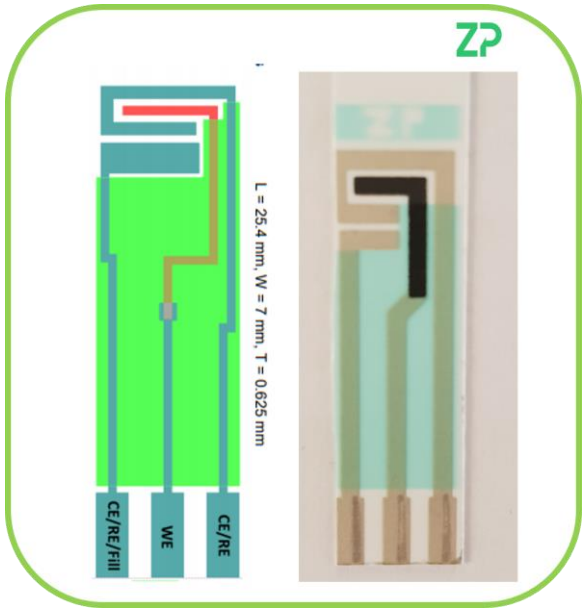
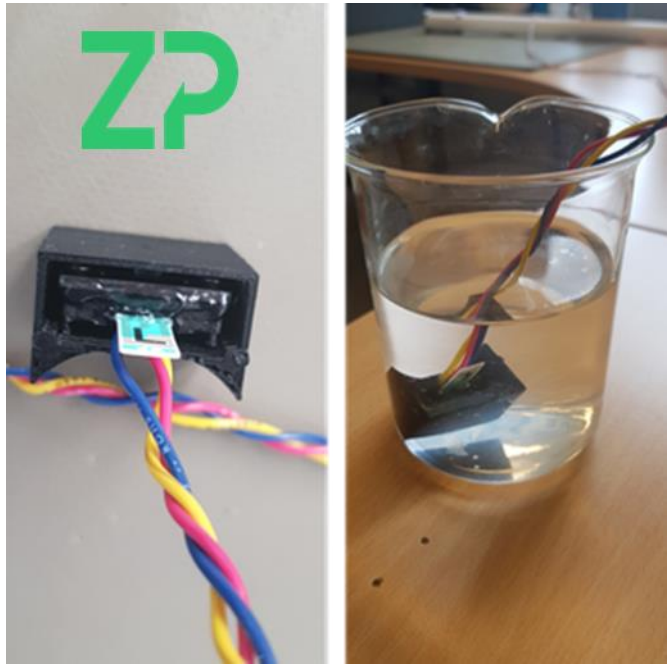
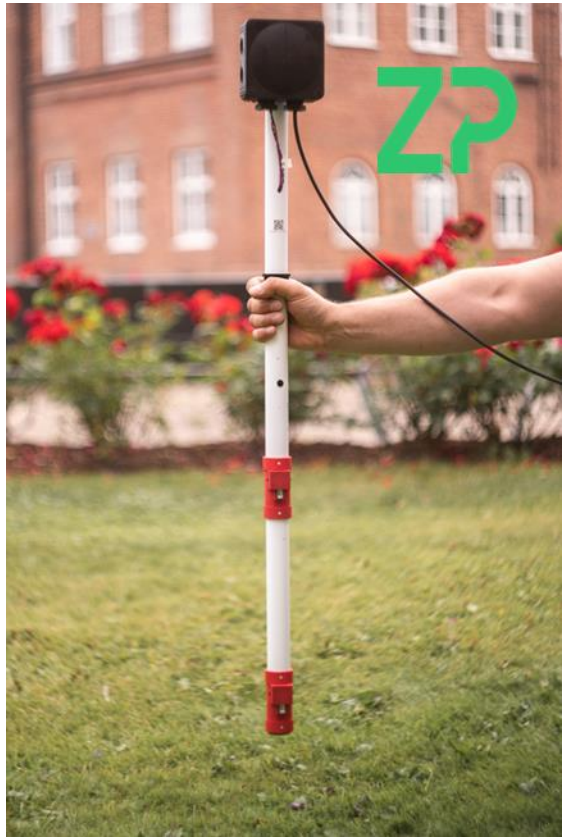
Progression of the ZP nitrate sensor







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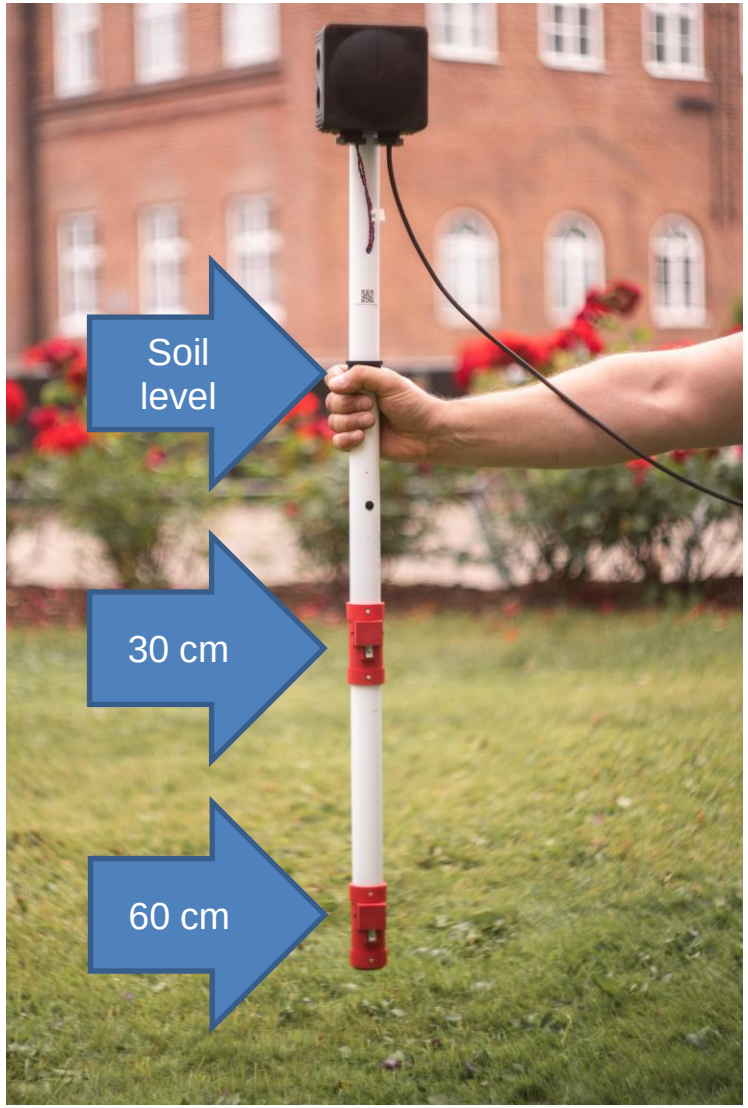
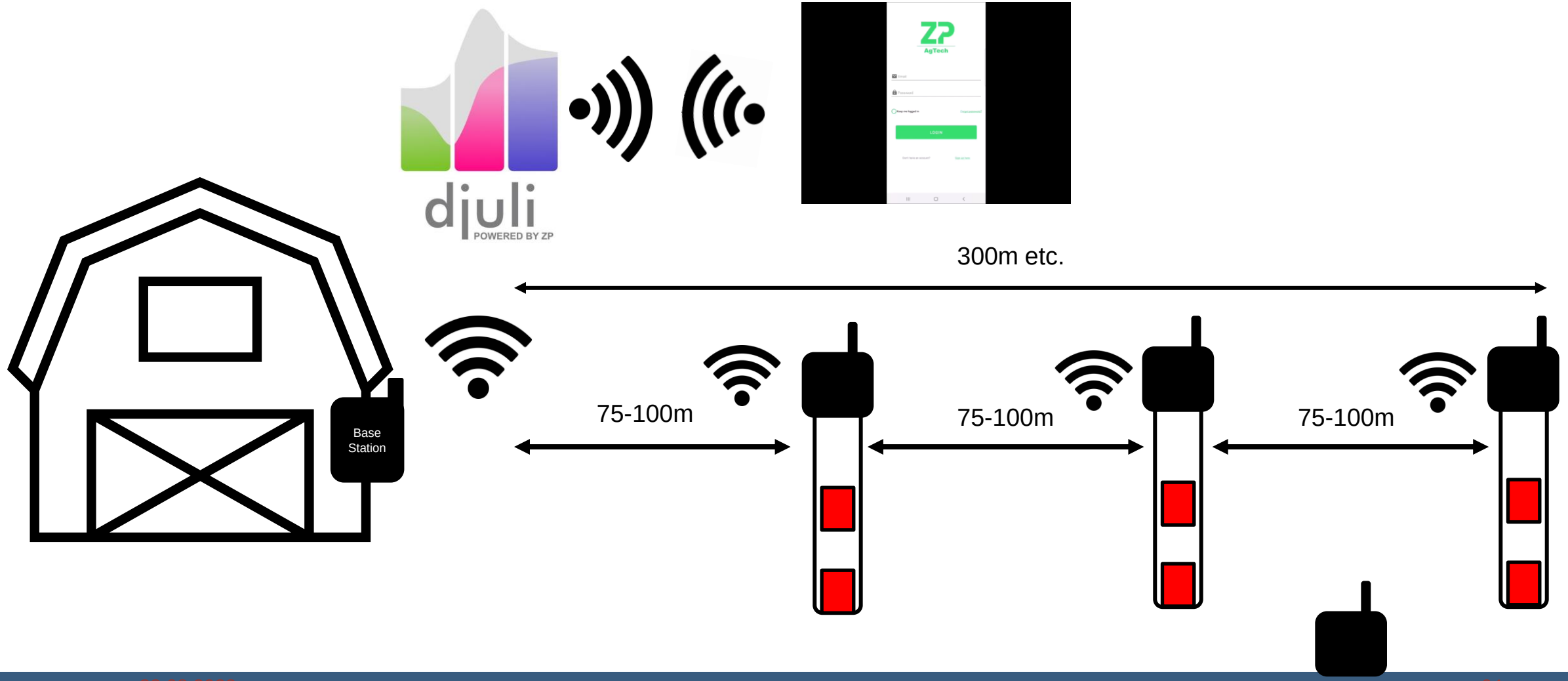


Soil Nitrate Sensor Mesh Starter Kit – WiFI - LoraWAN



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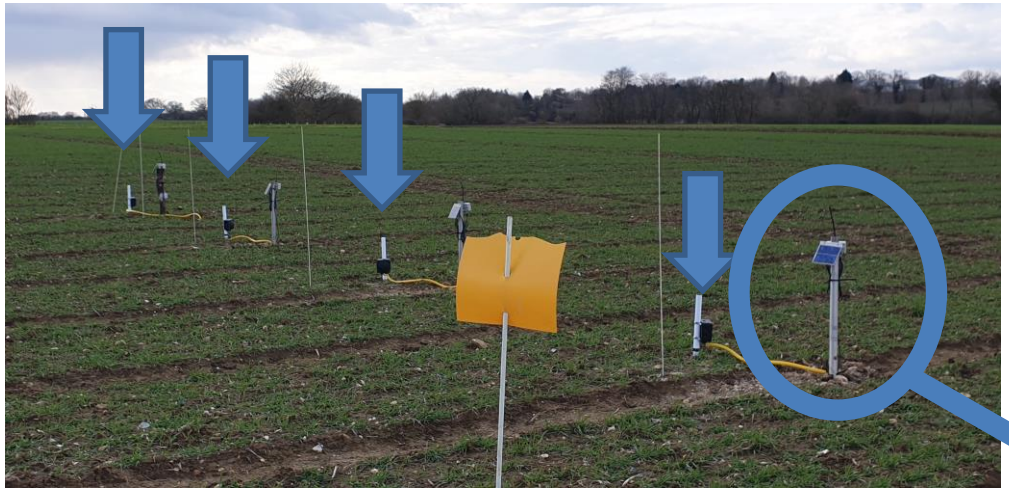
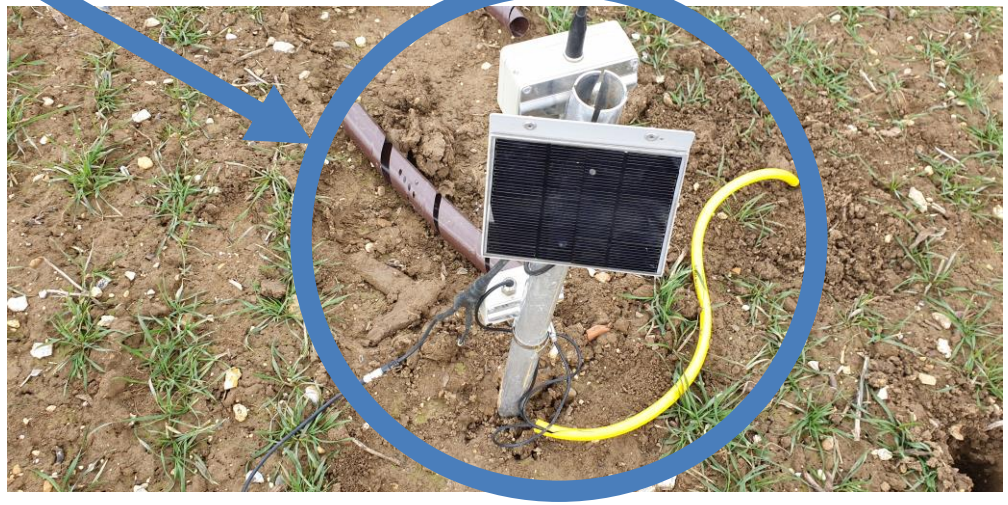
Field Installation





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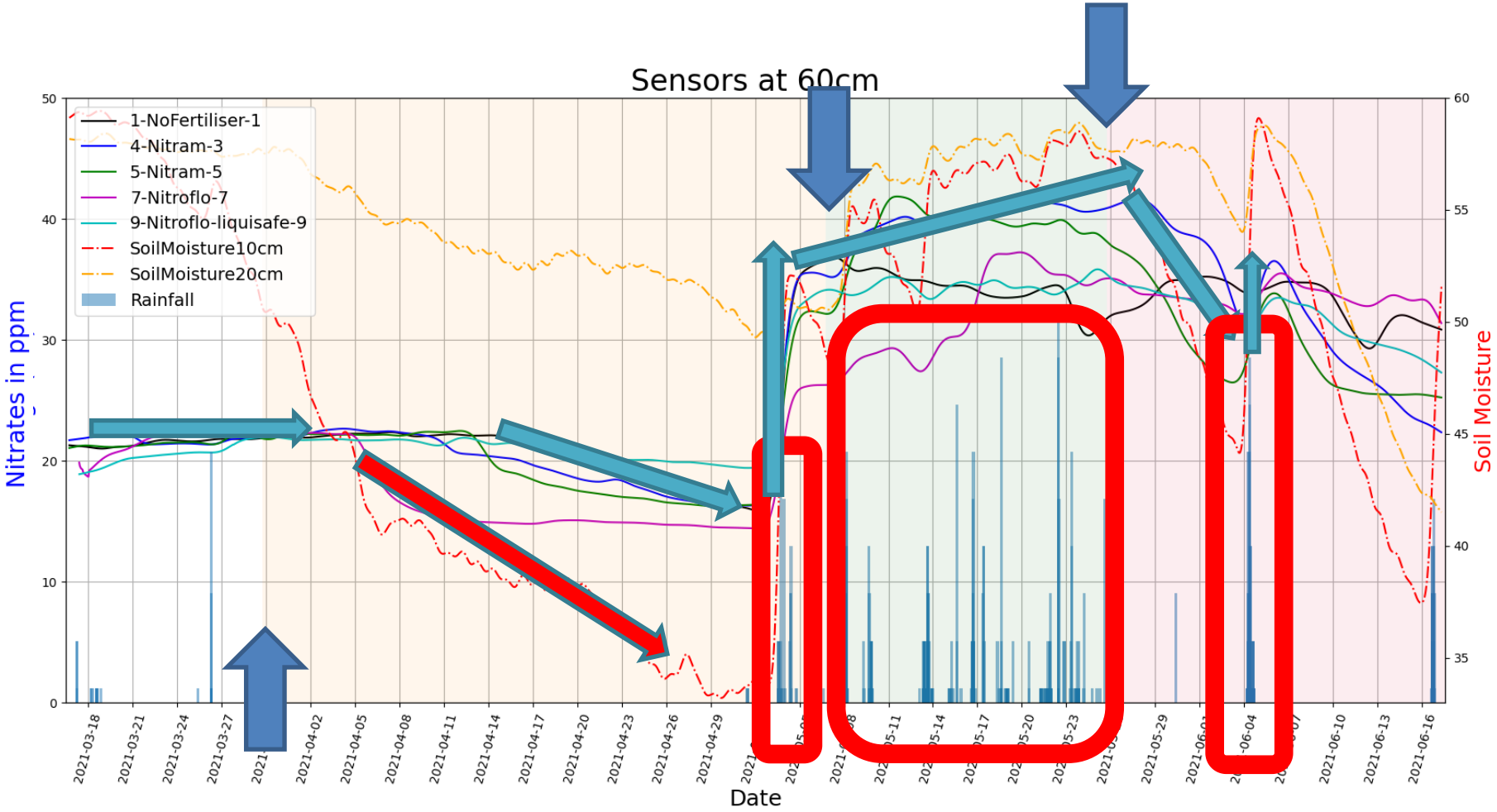
Data



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Case study one

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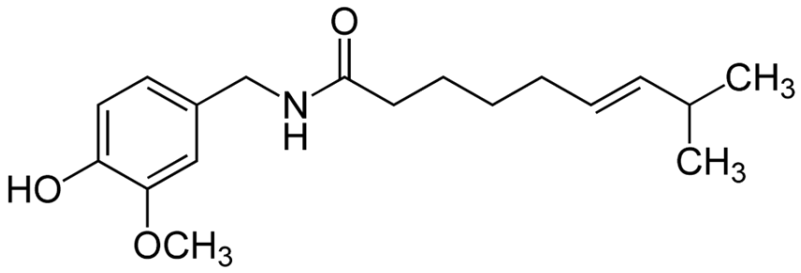
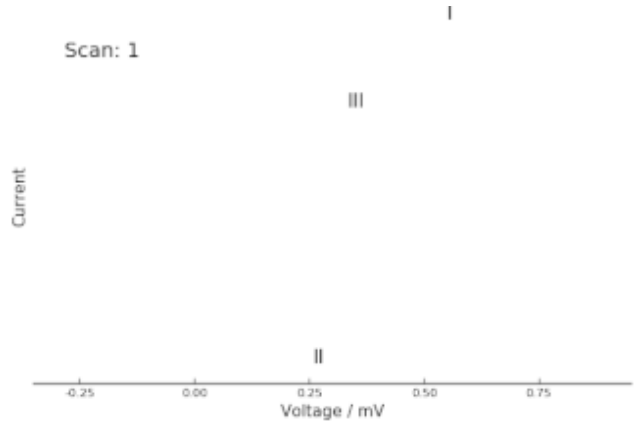
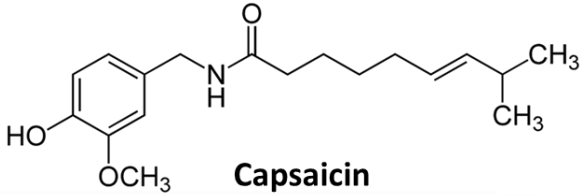
Background



Capsaicin



Measuring the hotness of chillies



Capsaicin

Analytical Testing

Panel Testing

Guessing

FoodSense

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FoodSense

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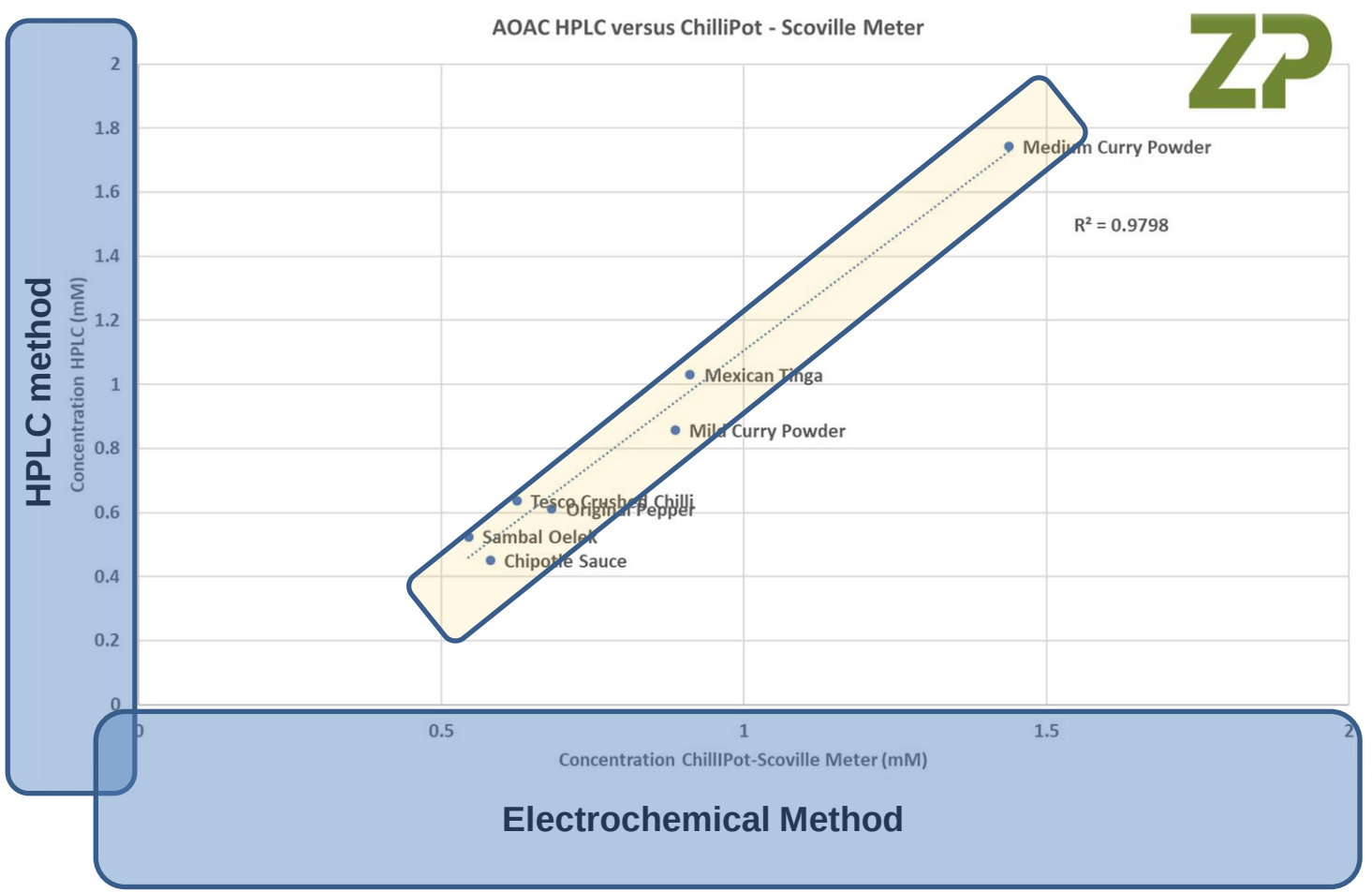
Validation of shopping list



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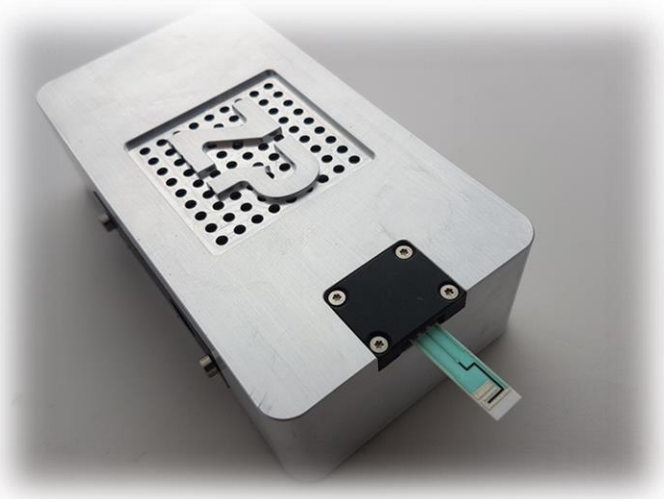
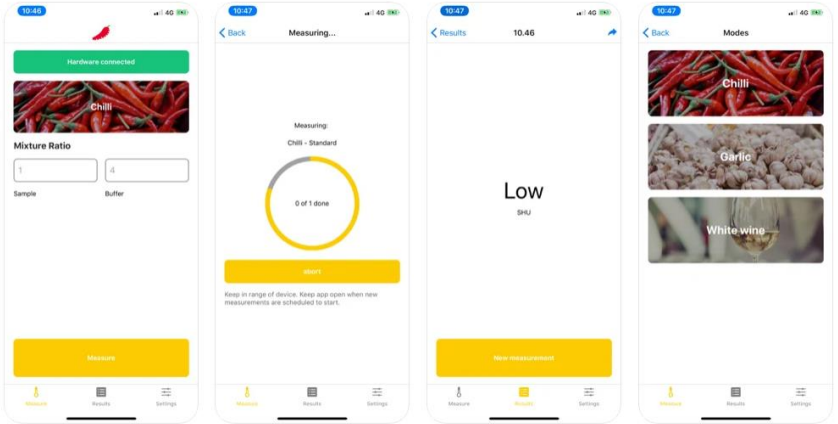
Iterations





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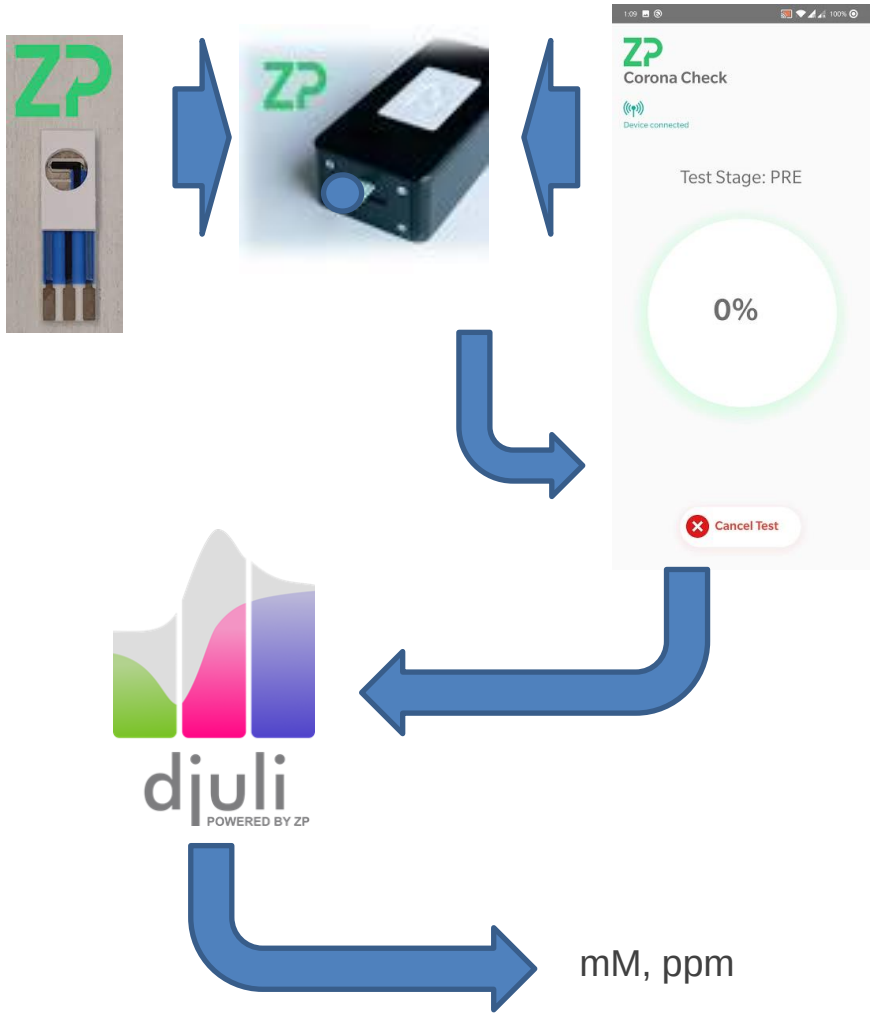
SenseItAll – Discrete Measurement



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TAS

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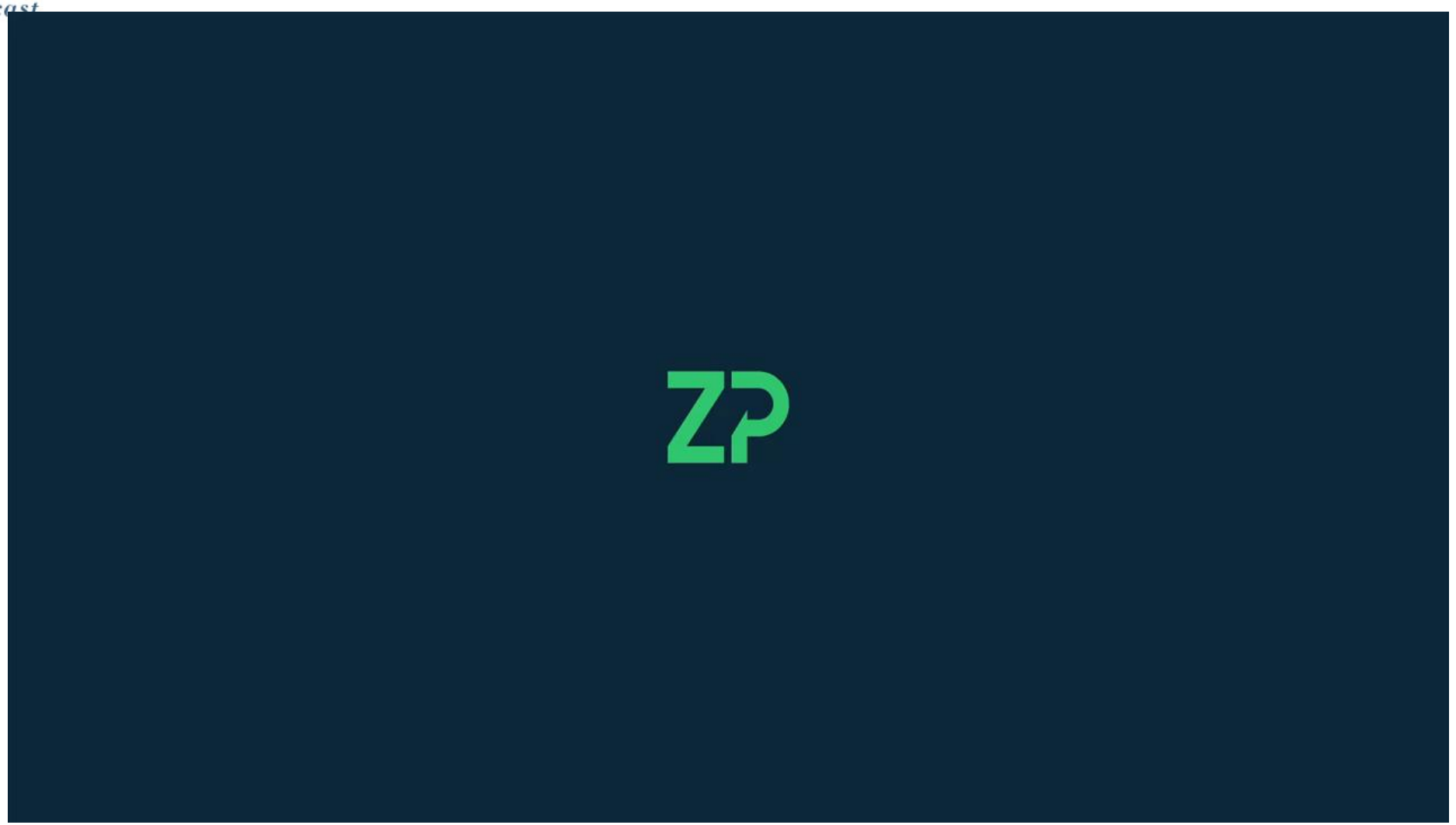
Nitrate



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Call to action

All the easy stuff is done, time for biology , biochemistry and chemistry

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Thank you

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