



# SARS-CoV-2 Point of Care Sensing Platform for Mutation Identification



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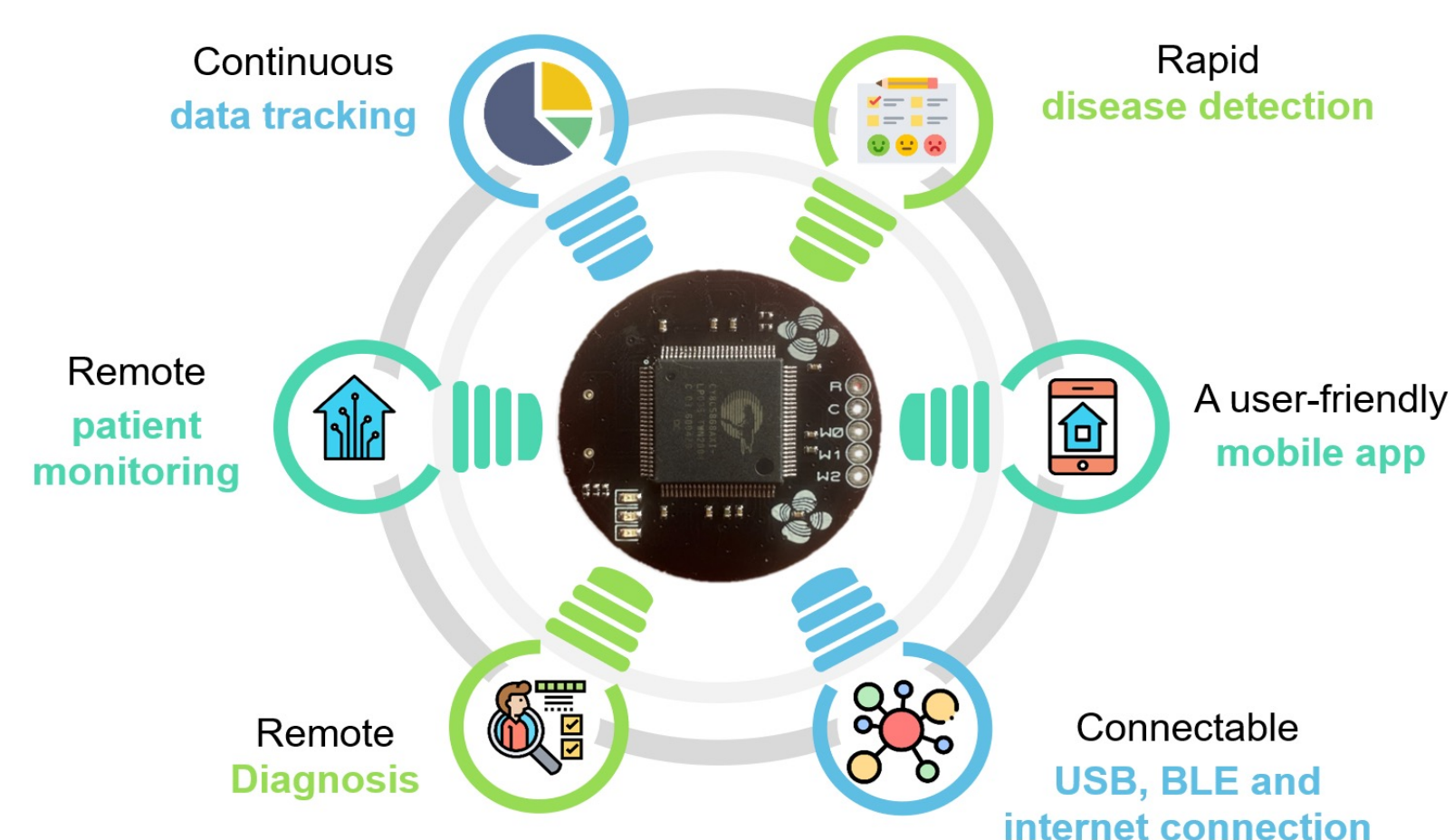
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## Abstract

- A miniaturized and portable sensor having **SARS-CoV-2 receptors**, enabling a **point of care (PoC) system** platform for three SARS-CoV-2 variants: **alpha (B.1.1.7)**, **beta (B.1.351)**, and **delta (B.1.617.2)**.
- Accurate, rapid, and fully integrated **wireless readout electronic system** with **smartphone data visualization**.
- Sensitive detection of SARS-CoV-2 with a limit of detection (LOD) of **5.14 and 2.09 ng/mL** for the S1 and S2 proteins in the linear range of 1.0 - 200 ng/mL, respectively.
- Successful COVID-19 diagnosis based on a clinical study with **63 nasal swab samples**.
- Our point of care diagnostic system is comparable to state-of-the-art **RT-PCR**, antibody blood, and IgG and IgA ELISA test results.

## Introduction

Monitoring the pandemic remains critical to efficiently manage the situation. As a crucial cellular receptor, Angiotensin-converting enzyme 2, known as ACE2, enables the direct entry the virus into the host cell.



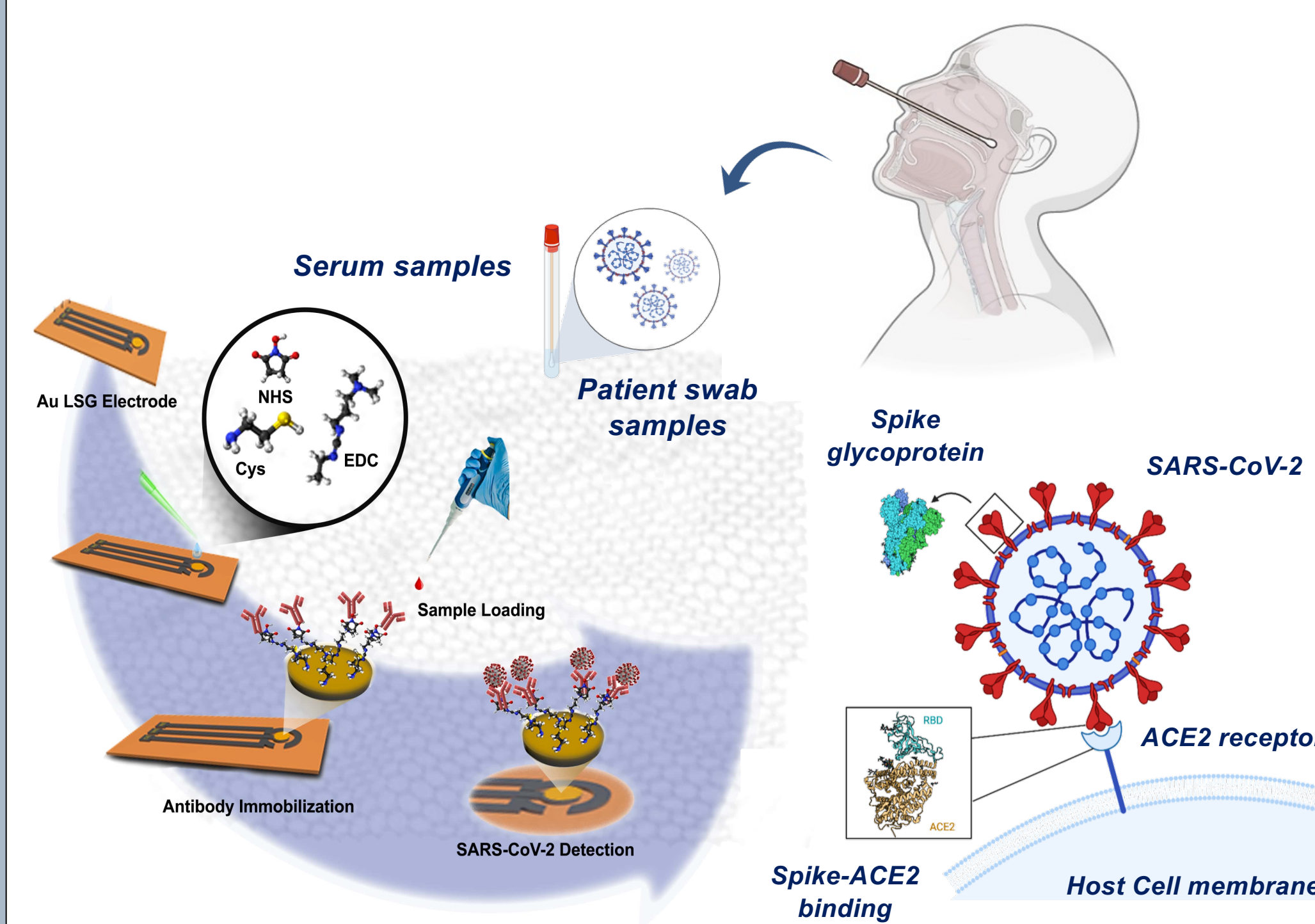
Here we describe a method to identify variants **alpha**, **beta** and **delta**, from the **United Kingdom**, **South Africa** and **India**. We achieve an accuracy of **99.37 % accuracy** by using the **Tiny Machine Learning** approach.



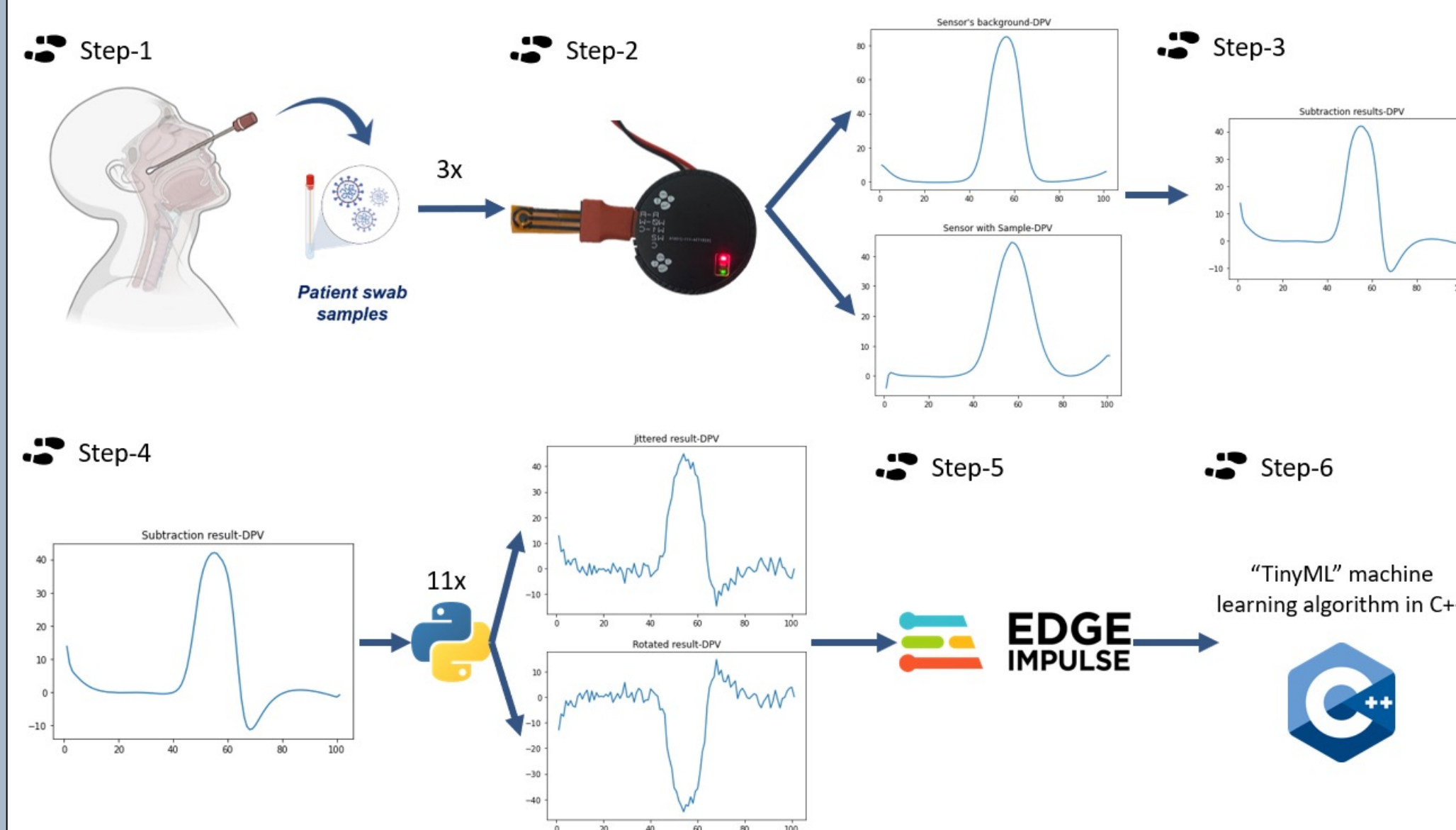
## Materials and Methods

### Sample collection and sensor preparation

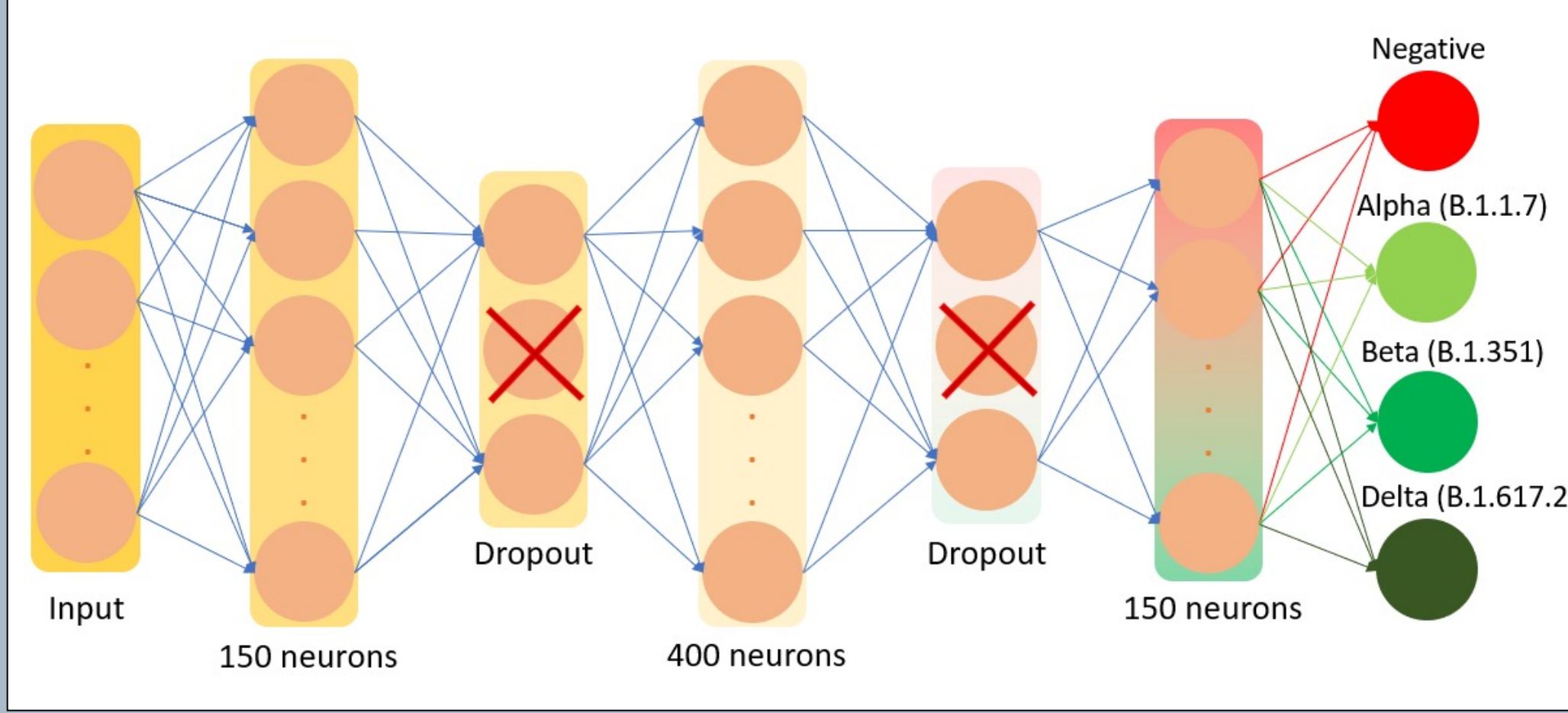
- Laser-scribed graphene (**LSG**) sensors are coupled with gold nanoparticles (**AuNPs**).



### Tiny Machine Learning (TinyML) enabled Device

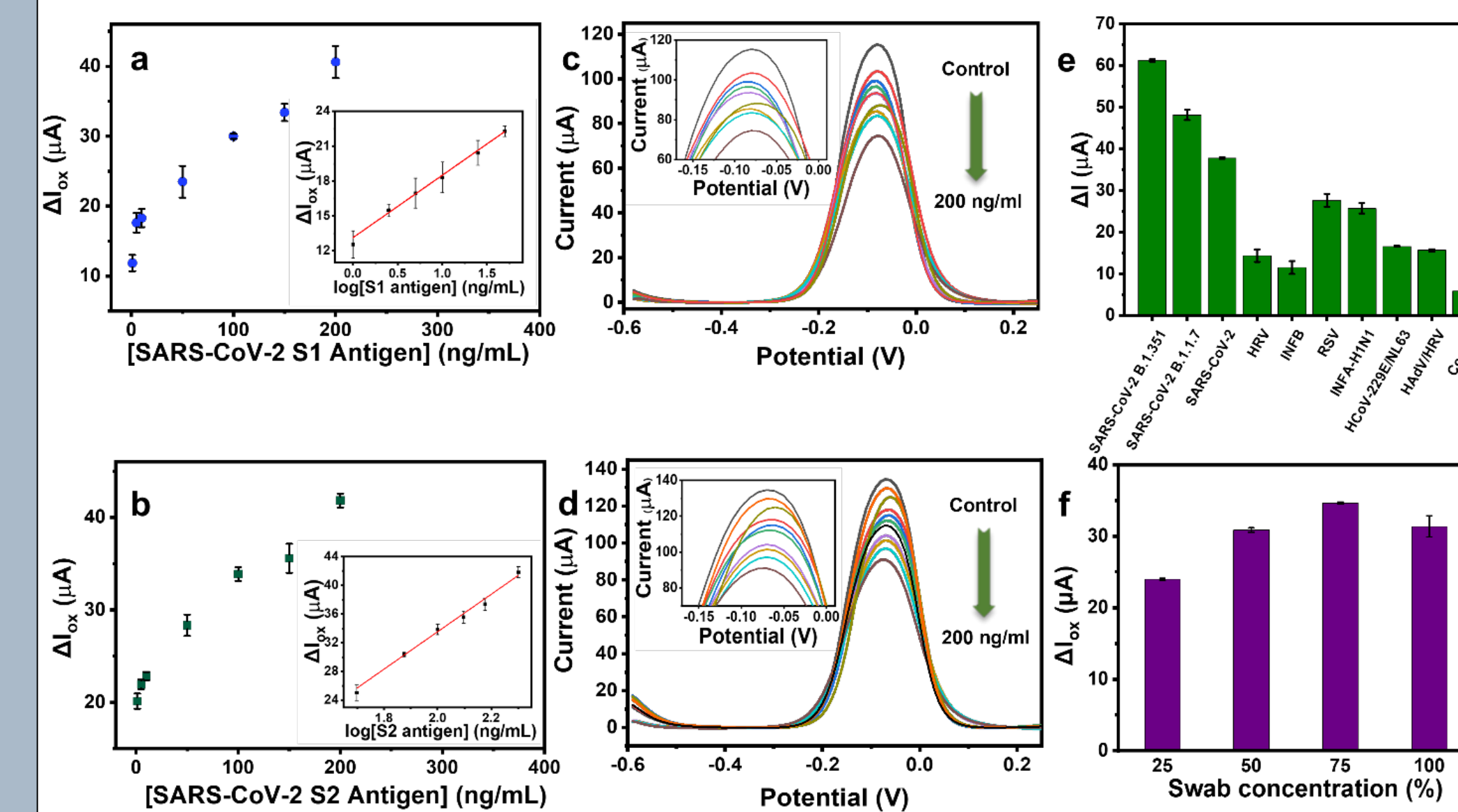


- Dataset of **4,224 Differential pulse voltammetry (DPV) samples** generated using **data augmentation**.
- The dataset was divided in **79% for training** and **21% for validating the algorithm**.
- The size of the TinyML algorithm created is **153.5KB**.
- With the additional code, **70.45% of the flash memory** was used.



## Results

### Sensing performance and sensitivity



✓ **ACE2** can recognize **S** proteins in mutations with **higher accuracy**.

✓ **Higher S1 and S2 binding** observed in **alpha**, **beta** and **delta** variants.

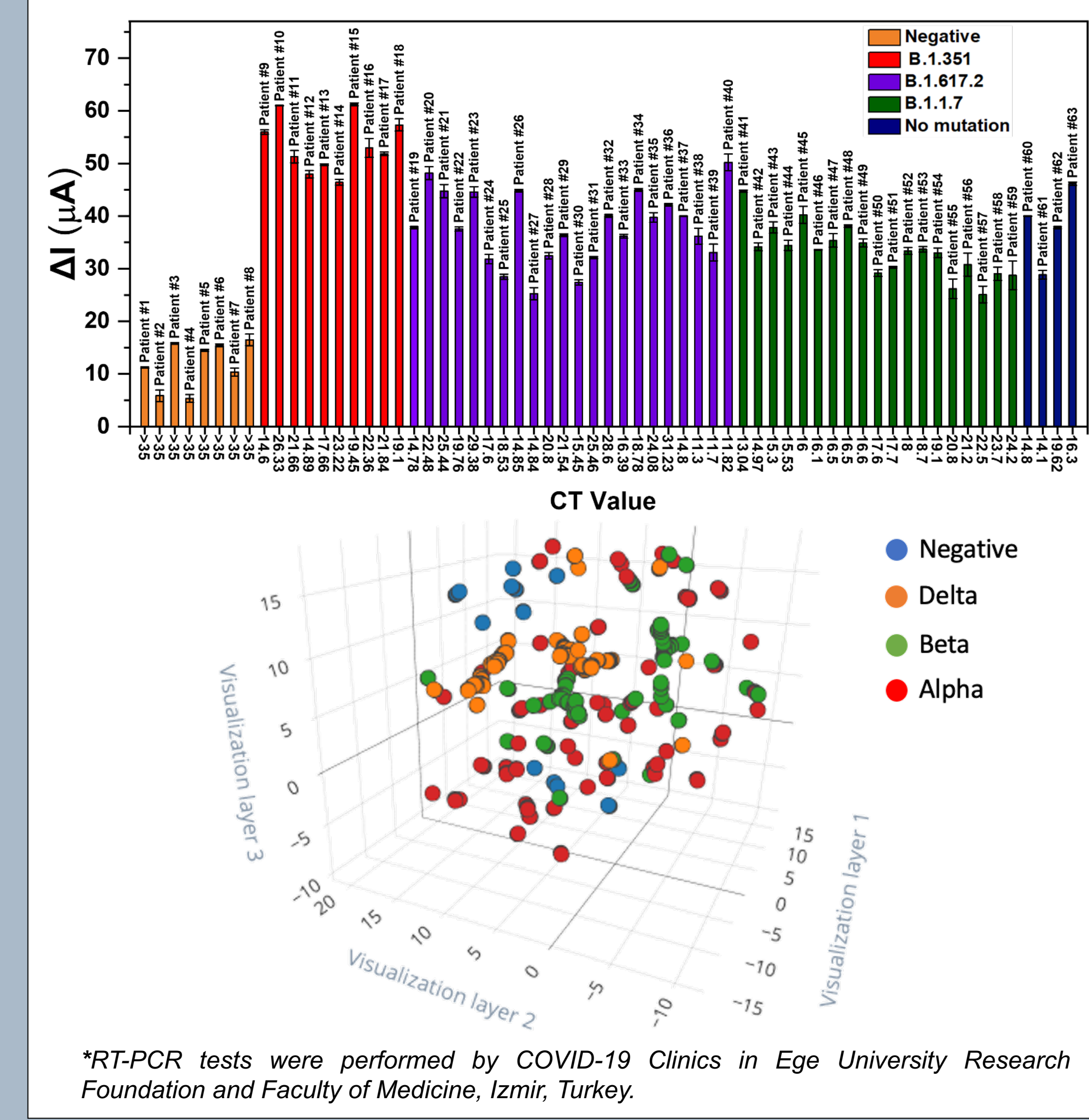
### Clinical trials

✓ **63 patient nasal swab samples** were tested with RT-PCR\* and our diagnostic system.

✓ Our diagnostic system has **100% agreement with RT-PCR** test.

✓ **98.7% accuracy** in inferring Beta (B.1.351) variant, **99.5% accuracy** in inferring Alpha (B.1.1.7) variant, **100% accuracy** in inferring Delta (B.1.617.2) variant, **98.9% accuracy** for control (negative) patients

✓ **~1 minute** for DPV and **20ms** for inference.



\*RT-PCR tests were performed by COVID-19 Clinics in Ege University Research Foundation and Faculty of Medicine, Izmir, Turkey.

## Conclusion

- **Early, low-cost, easy-to-use** PoC detection of disease biomarkers is critical for managing **global health issues**.
- Identification of mutations, **alpha**, **beta** and **delta** originated from the **United Kingdom**, **South Africa** and **India** with POC device.
- The validation of device performance as a **self-diagnostic platform** was achieved by a **machine learning (TinyML) algorithm**.
- We have achieved a low cost **< \$ 50 PoC platform**
- The presented solution provides **fast SARS-CoV-2 variant detection** ( ~1minute) with **high accuracy** between positive and negative case (100% agreement with RT-PCR)
- **Our PoC system offers a potential platform for future SARS-CoV-2 variants**.

## References

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- [2] Beduk T, Beduk D, de Oliveira Filho JI, Zihnioglu F, Cicek C, Sertoz R, Arda B, Goksel T, Turhan K, Salama KN, Timur S. Rapid point-of-care COVID-19 diagnosis with a gold-nanoarchitecture-assisted laser-scribed graphene biosensor. Analytical chemistry. 2021 Jun 3;93(24):8585-94.



[1] [2] Sensors Lab

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