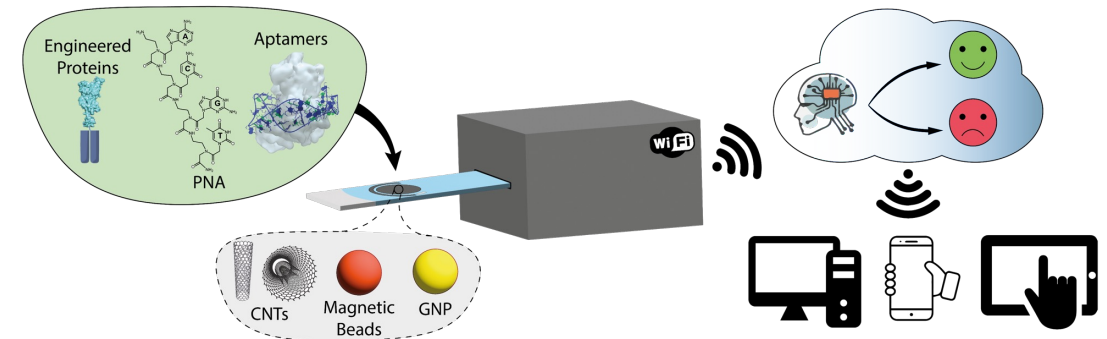# Bringing the Lab to the Patient: Portable Smart Biosensors for Point-of-Care Diagnostics

Simone Fortunati

Department of Chemistry, Life Sciences and Environmental Sustainability
University of Parma

simone.fortunati@unipr.it

Outline

Point of care testing
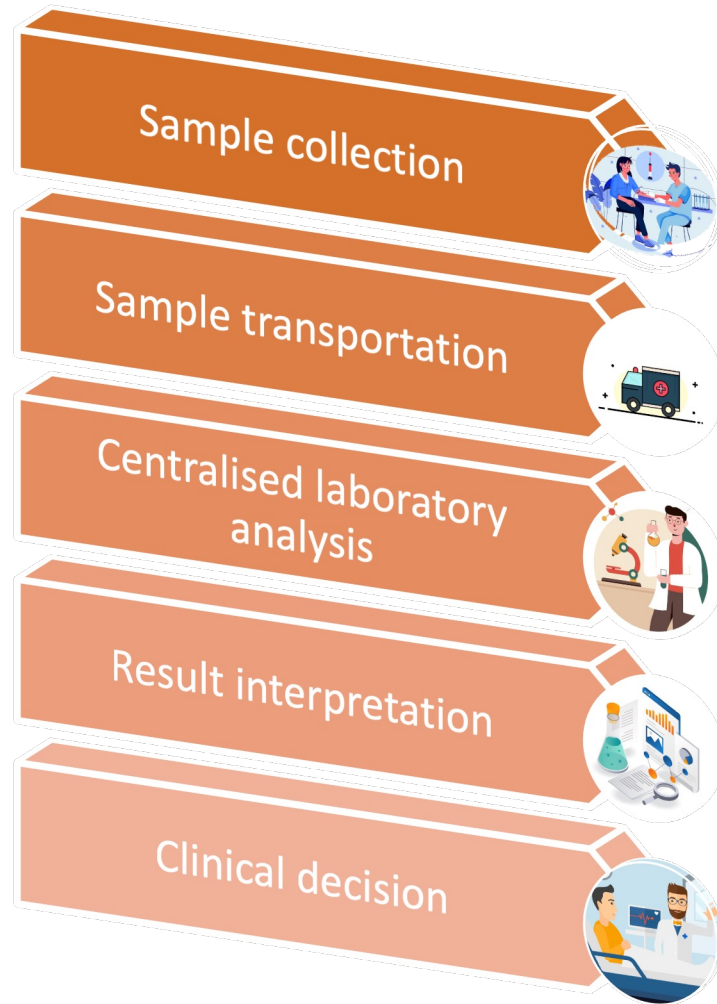
TRADITIONAL CLINICAL DIAGNOSTICS

POINT OF CARE DIAGNOSTICS

Sample collection

Sample transportation

Centralised laboratory analysis

Result interpretation

Clinical decision

Sample collection

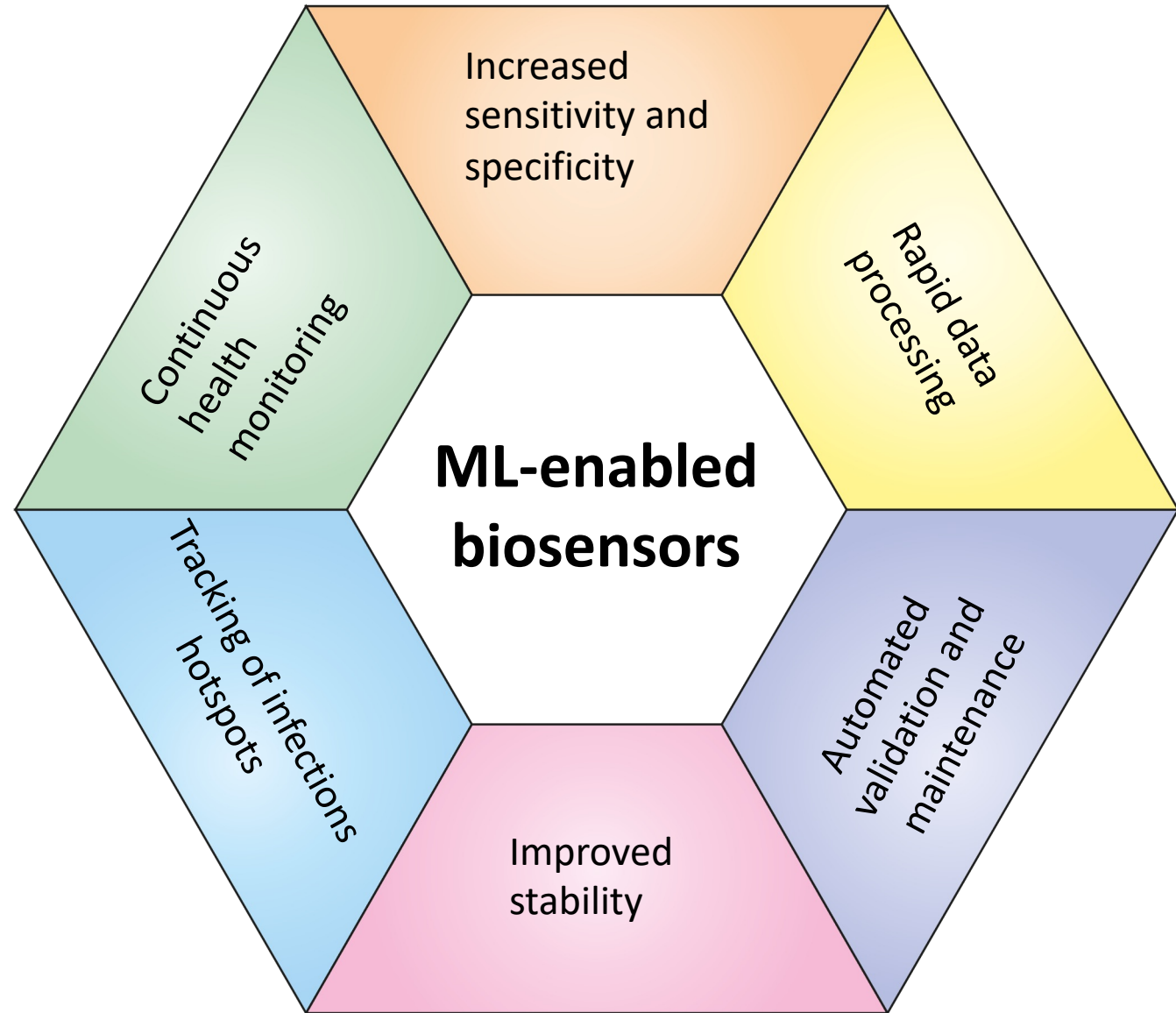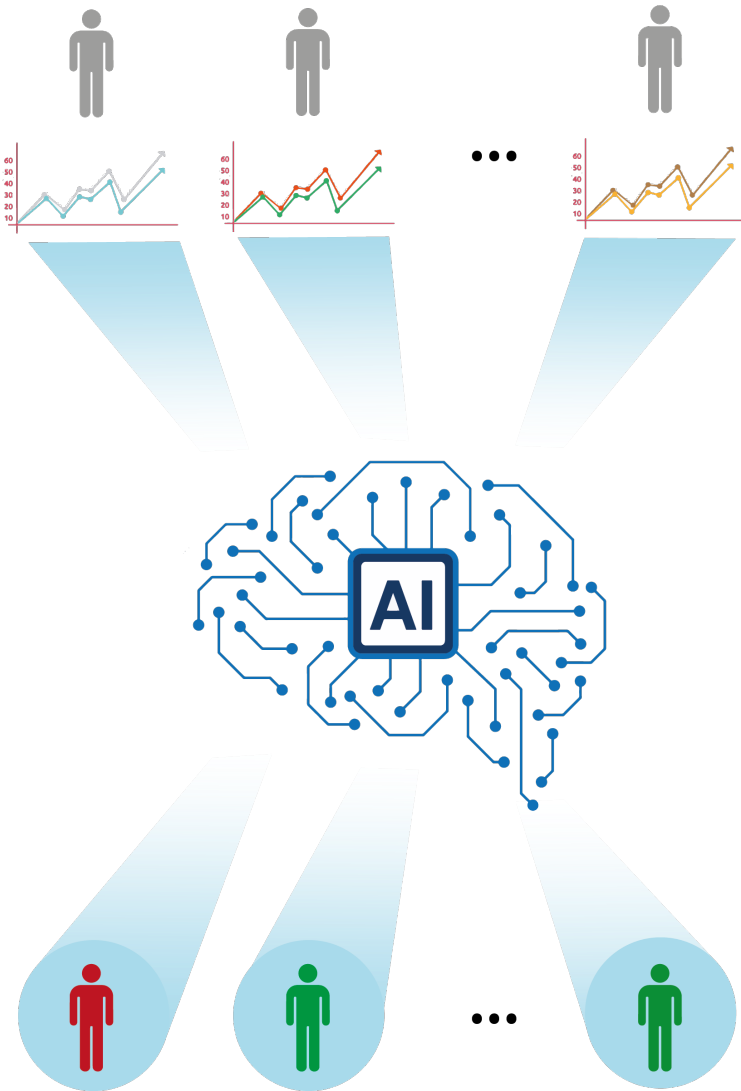Analysis and result visualisation

Clinical decision
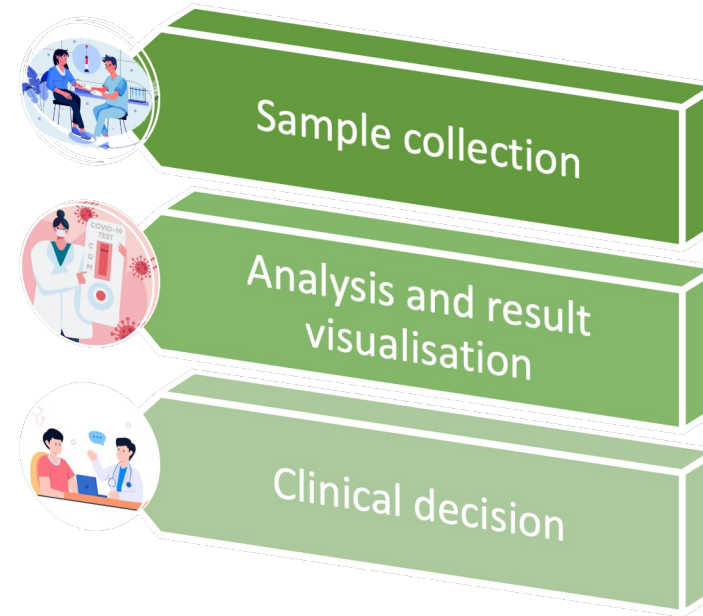
Criteria

Kettler, H. et al. UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases, TDR/STI/IDE/04.1 (2004).
Land, K.J. *et al. Nat Microbiol* **4**, 46–54 (2019).
Solano, D., Camacho-Leon, S. *Microsyst. Technol.* **31**, 1289–1301 (2025).

AI implementation

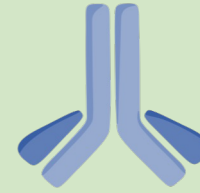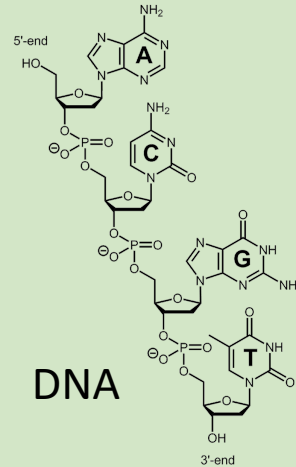Bhaiyya, M. et al. *ACS Sensors* **9**, 4495–4519 (2024).
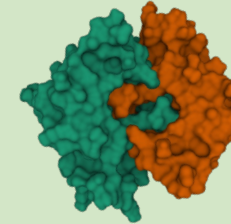
Electrochemical Biosensors for POCT

Receptor

Materials

Transduction mechanism

Signal acquisition

DNA

Antibodies

Proteins

Enzymes

PNA*

Engineered proteins

*Synthesized by the group of Prof. R. Corradini (University of Parma)

Electrochemical Biosensors for POCT
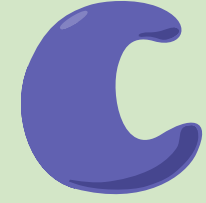

Receptor

Materials
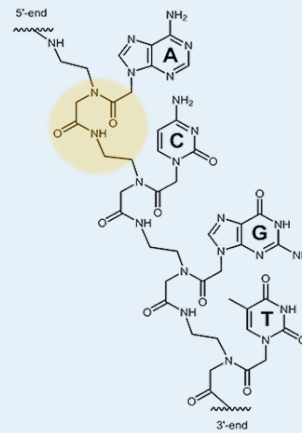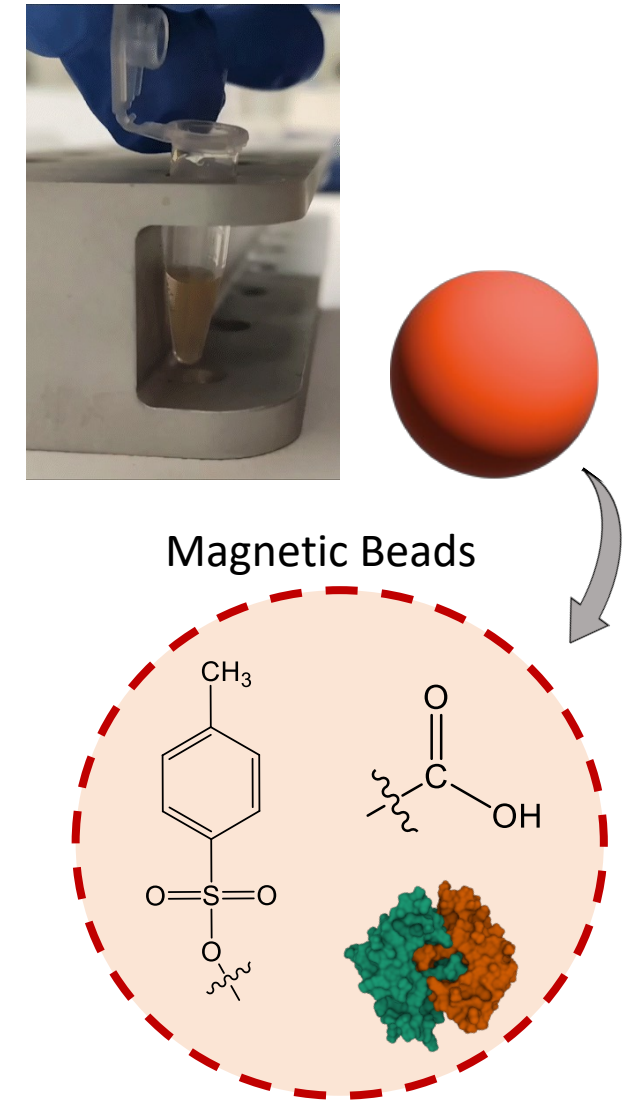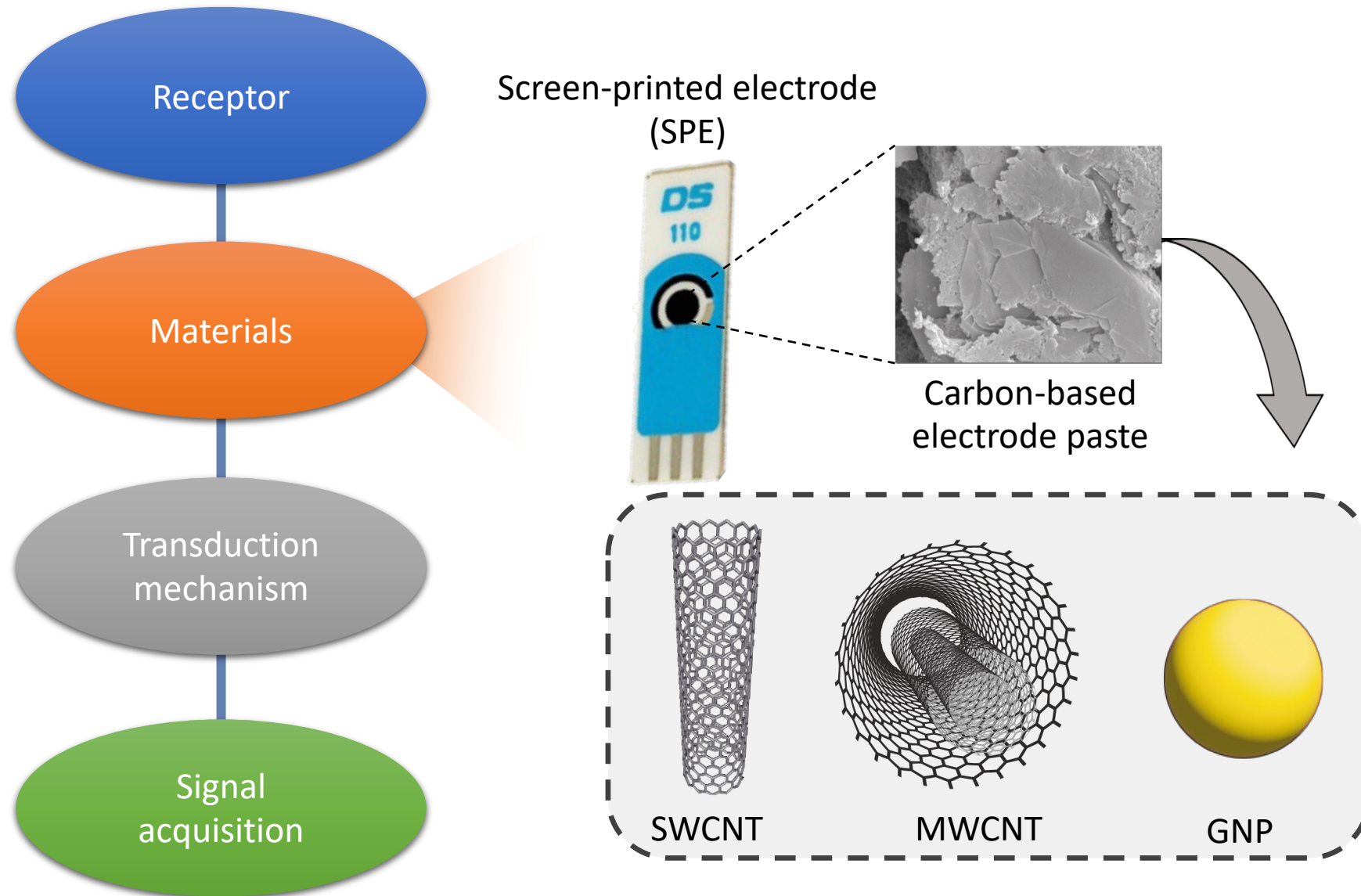
Transduction mechanism

Signal acquisition

Screen-printed electrode (SPE)

Carbon-based electrode paste

SWCNT   MWCNT   GNP

Magnetic Beads

CH₃

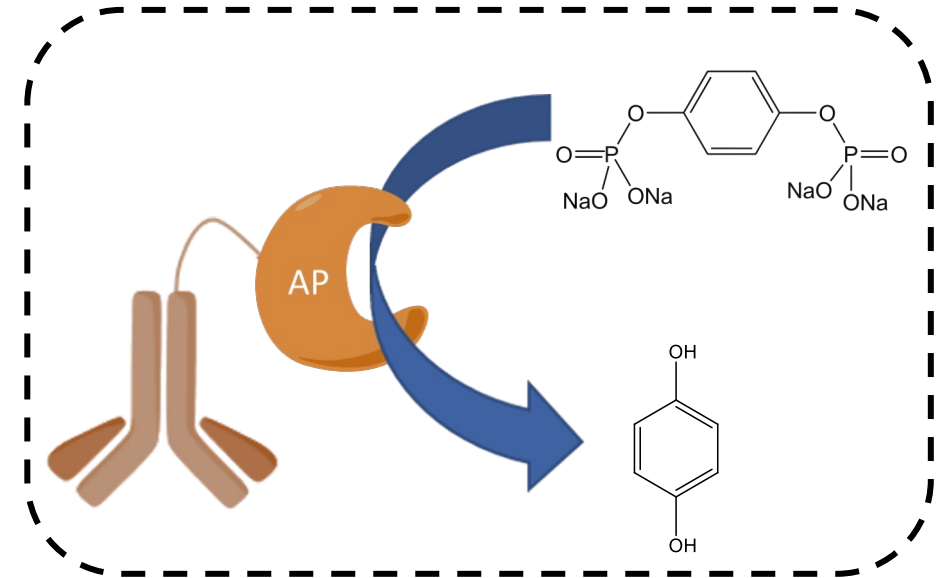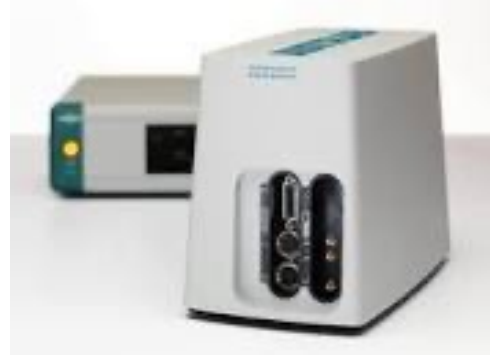Fortunati, S. et al. *Analysis & Sensing* **4**, (2023).

Electrochemical Biosensors for POCT

Receptor

Materials

Transduction mechanism

Signal acquisition

AP

HQDP
Not electroactive

HQ
Electroactive

STRP
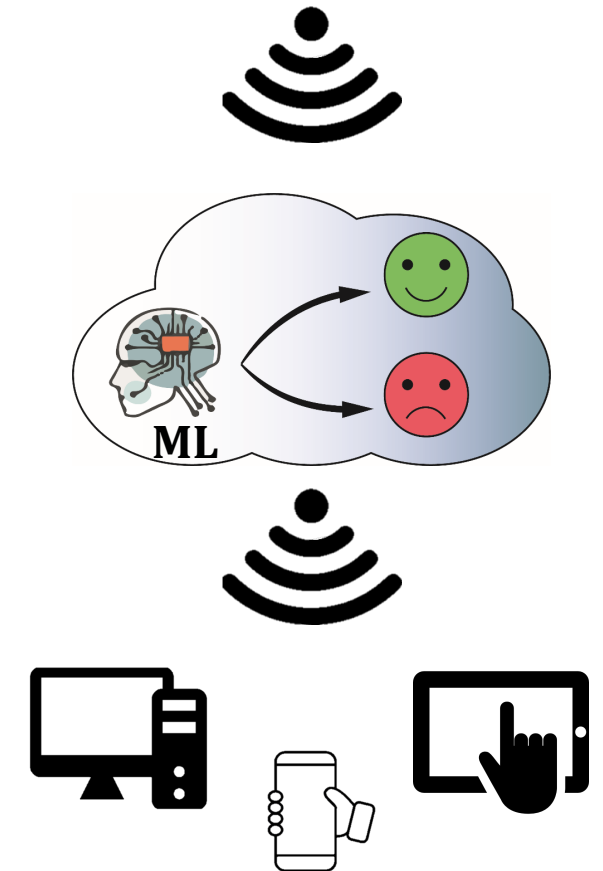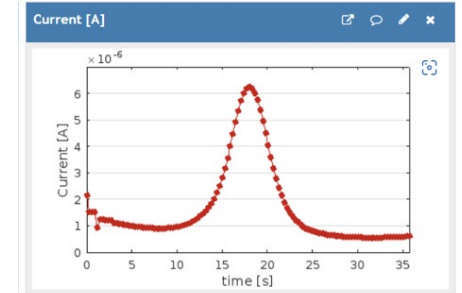Biotin
AP
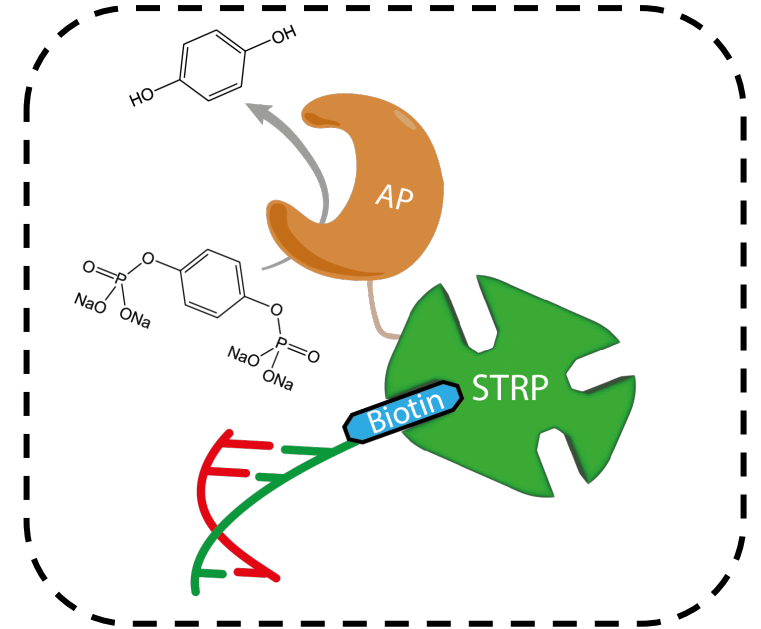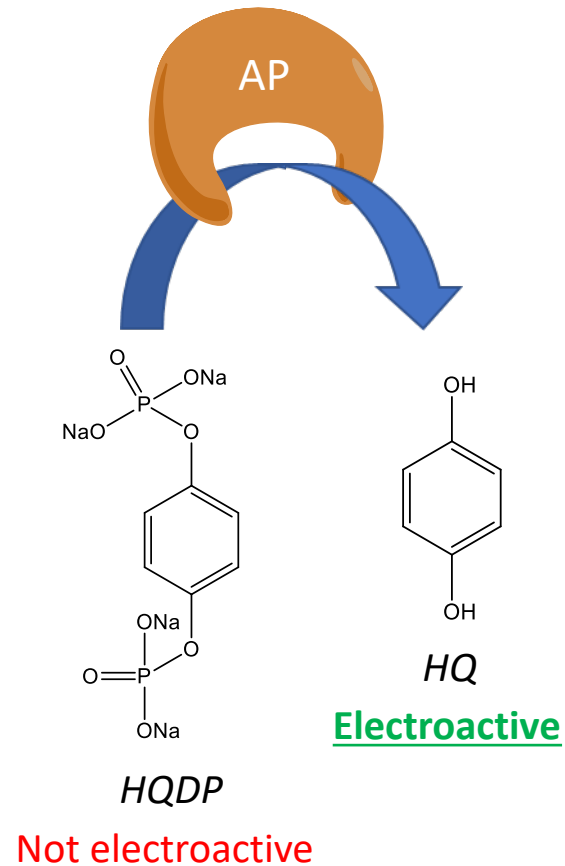
Electrochemical Biosensors for POCT

Benchtop Potentiostat
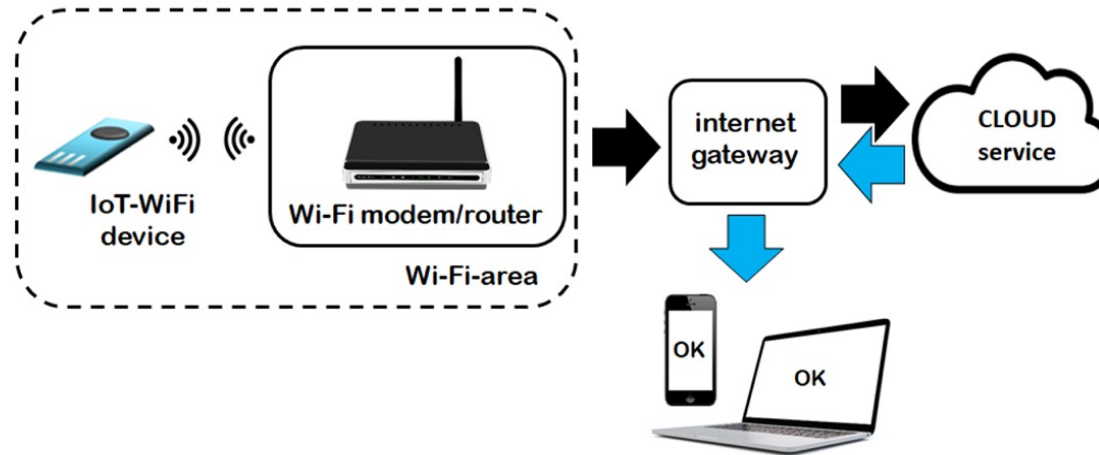
Smart IoT* devices

*In collaboration with Prof. I. De Munari and Prof. A. Boni (Department of Engineering and Architecture, University of Parma)

Receptor

Materials
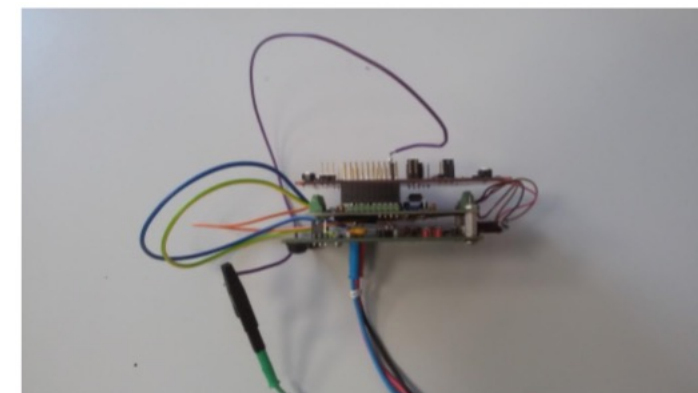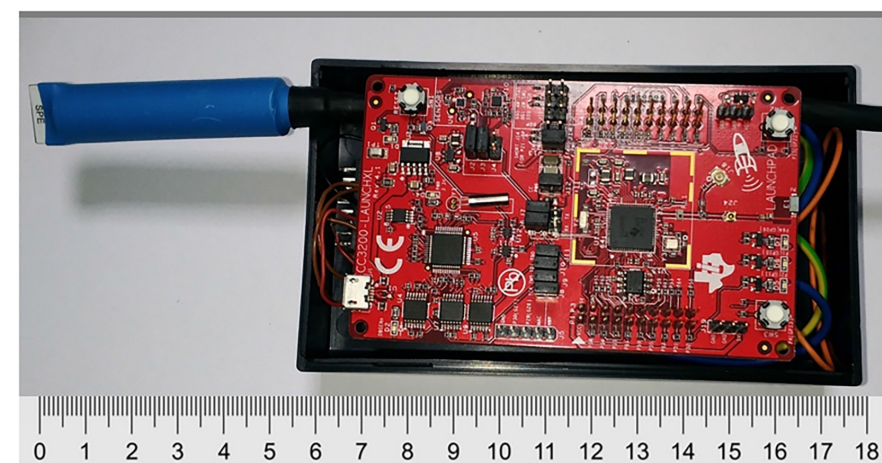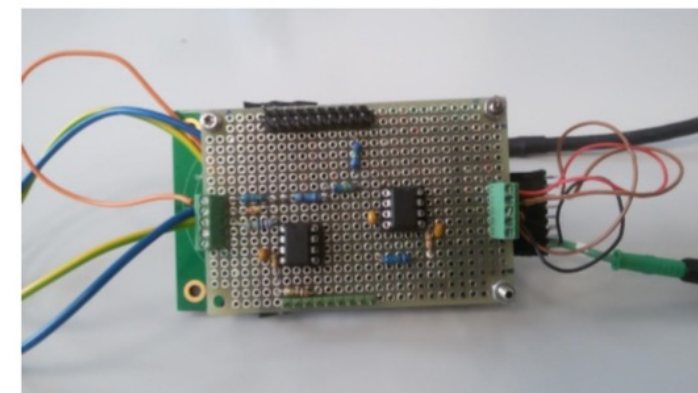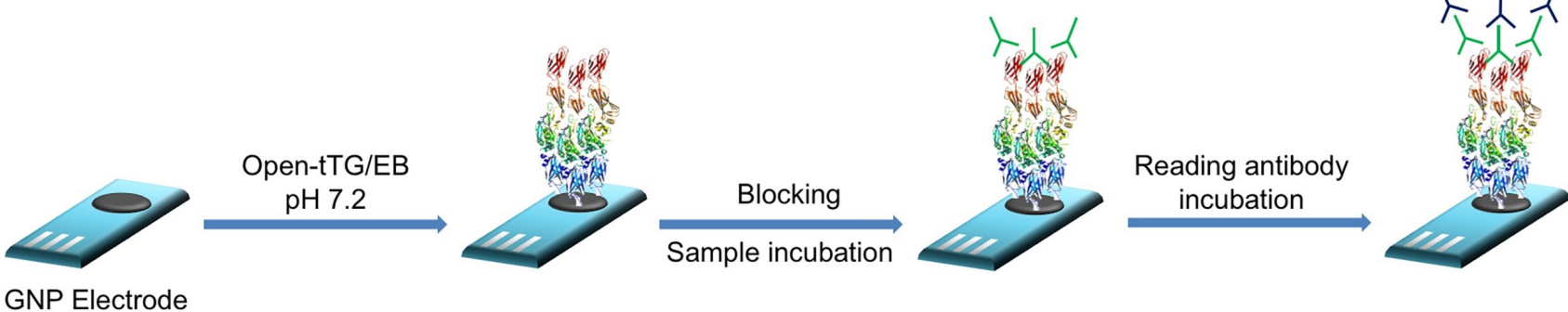
Transduction mechanism

Signal acquisition

Outline

An integrated IoT-Wi-Fi board for remote data acquisition and sharing from innovative immunosensors. Case of study: Diagnosis of celiac disease

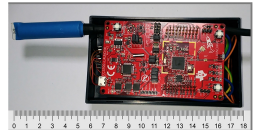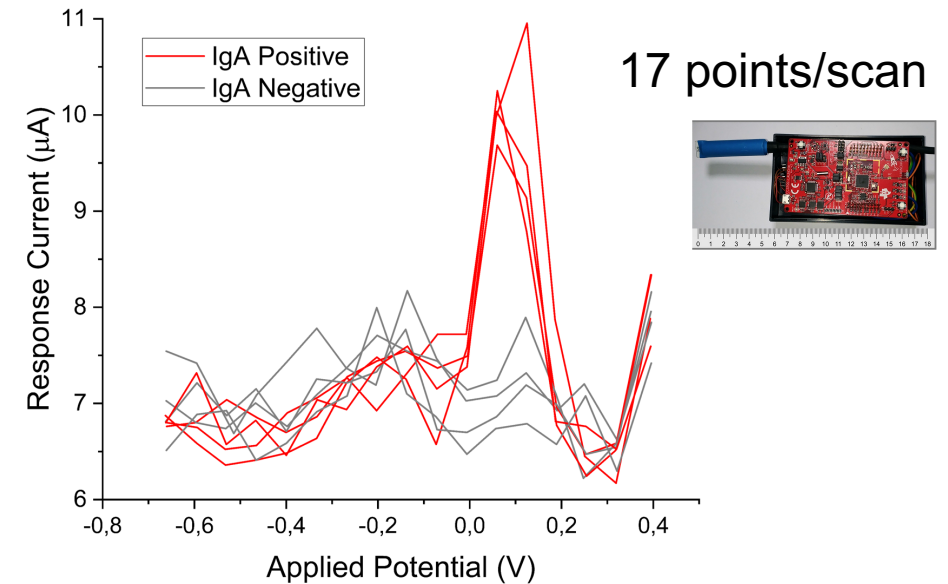Marco Giannetto[a,*], Valentina Bianchi[b,*], Silvia Gentili[a], Simone Fortunati[a], Ilaria De Munari[b], Maria Careri[a]
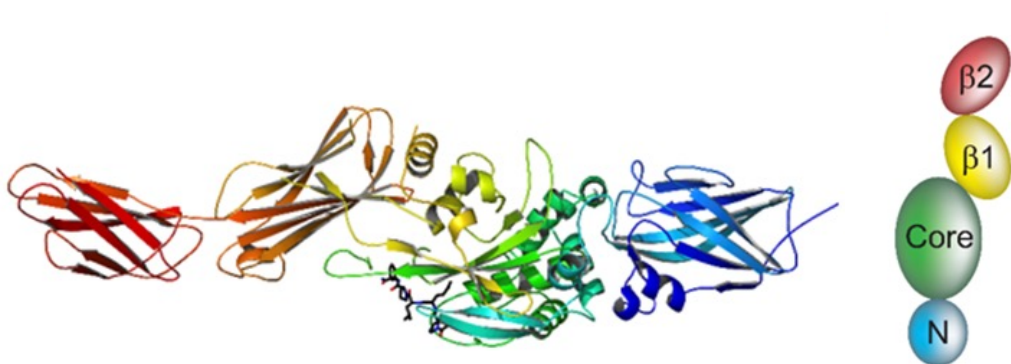
Open-tTG

Anti-tTG detection

Interactions and 95.0 Percent LSD Intervals

Open tTG® (μg mL^{-1})
- 4.58
- 9.16
- 18.3

P/N ratio vs Anti-H-IgA-AP (μg mL^{-1})

$y = 0{,}83(0{,}03)x + 5{,}94(0{,}48)$
$R^2 = 0{,}9938\ (n=15)$

$LOD_{IgA} = 3{,}2$ AU/mL
$LOD_{IgG} = 1{,}4$ AU/mL

Response Current (μA) vs IgA Concentration (AU/mL)

164 points/scan

IgA Positive
IgA Negative

Response Current (μA) vs Applied Potential (V)

17 points/scan

IgA Positive
IgA Negative

Response Current (μA) vs Applied Potential (V)

10

Anti-tTG detection

Interactions and 95.0 Percent LSD Intervals

Open tTG® (µg mL^{-1})
- 4.58
- 9.16
- 18.3

P/N ratio

Anti-H-IgA-AP (µg mL^{-1})

$y = 0,83(0,03)x + 5,94(0,48)$
$R^2 = 0,9938\,(n=15)$

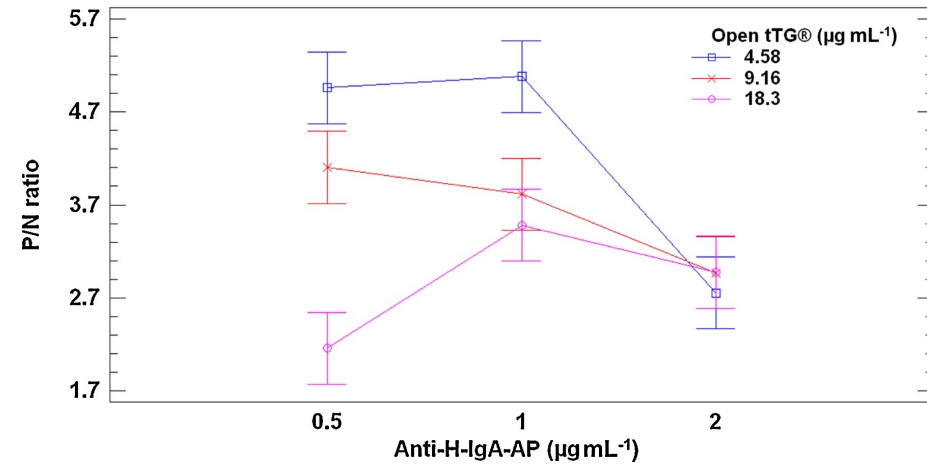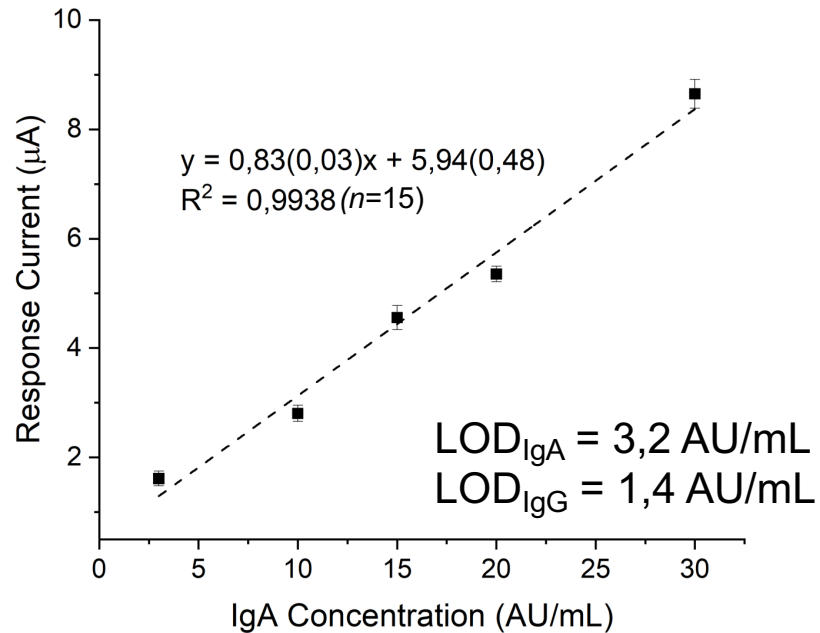$LOD_{IgA} = 3,2$ AU/mL
$LOD_{IgG} = 1,4$ AU/mL

Response Current (µA)

IgA Concentration (AU/mL)

IgA anti-tTG

Neg CTRL

Controllo

Pos CTRL

Peak current (Ampere) (X 0.000001)

IgG anti-tTG

Neg CTRL

Controllo

Pos CTRL

Peak current (Ampere) (X 0.000001)

A Wi-Fi Cloud-Based Portable Potentiostat for Electrochemical Biosensors

Valentina Bianchi[ID], Andrea Boni, Simone Fortunati, Marco Giannetto, Maria Careri, and Ilaria De Munari[ID], Member, IEEE
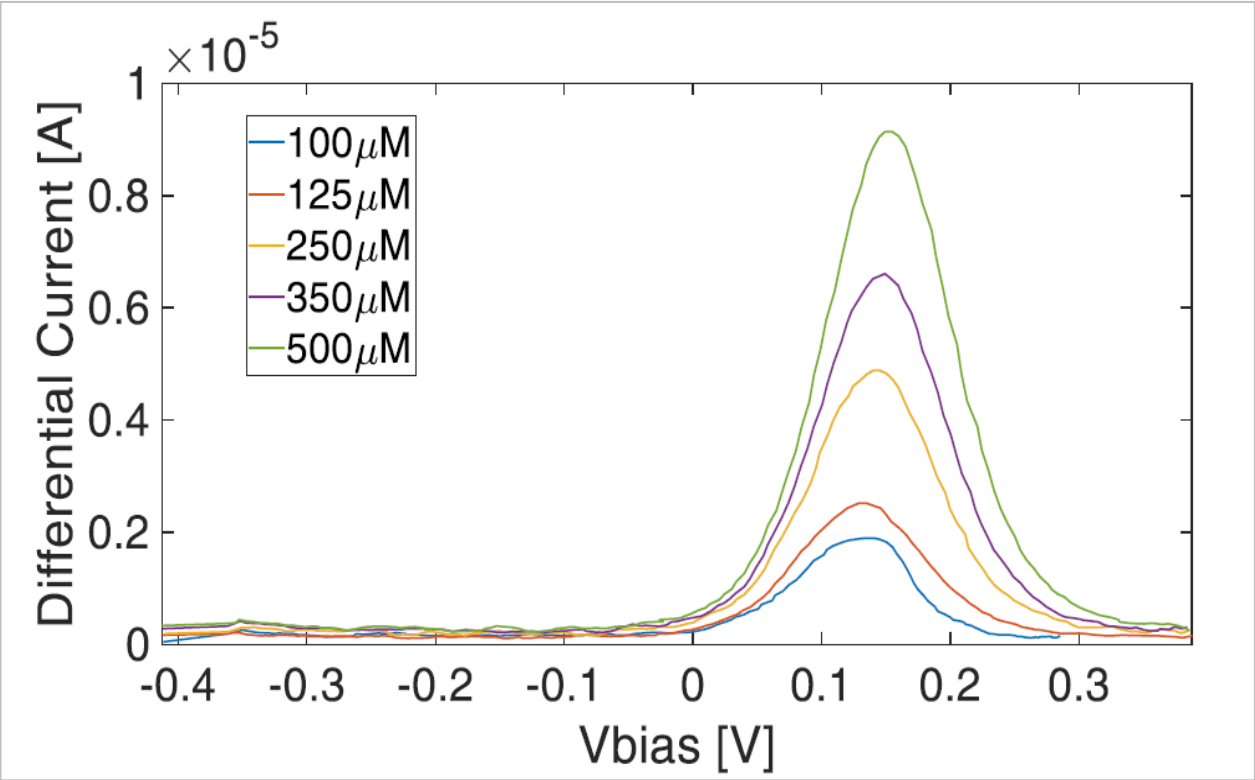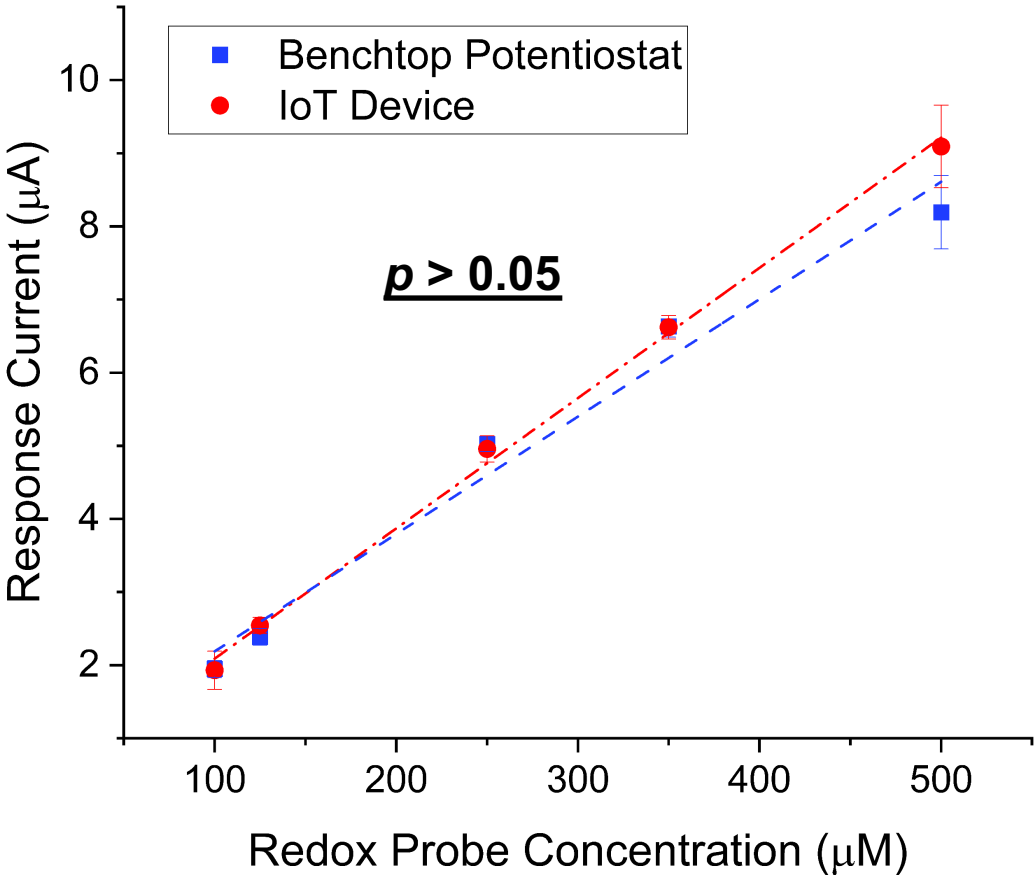

New custom-made Analog Front-End
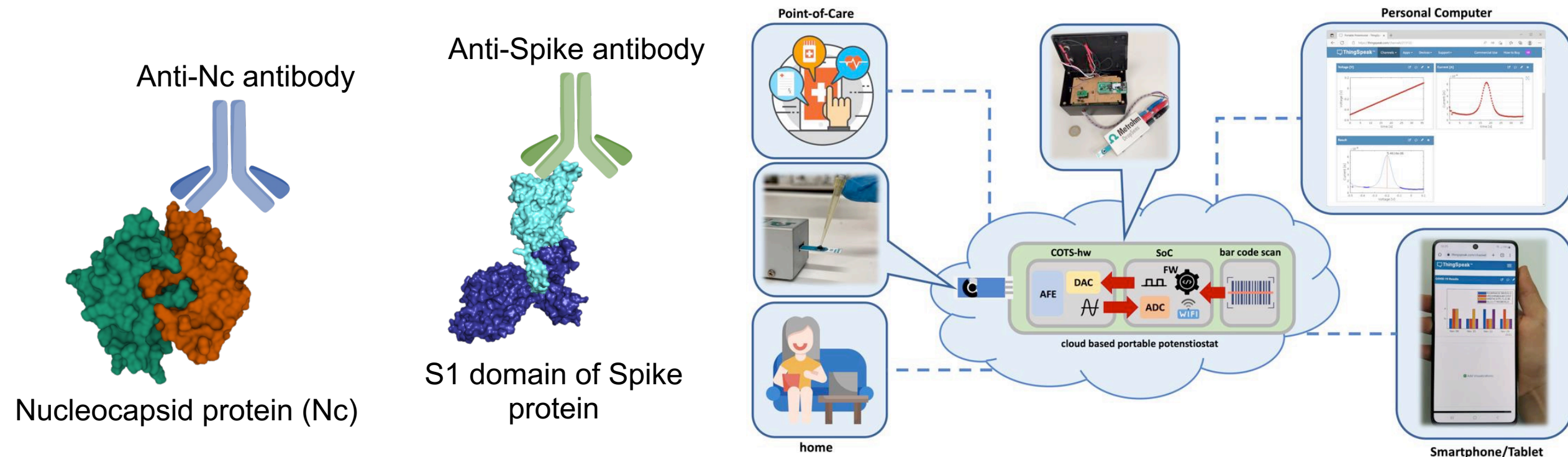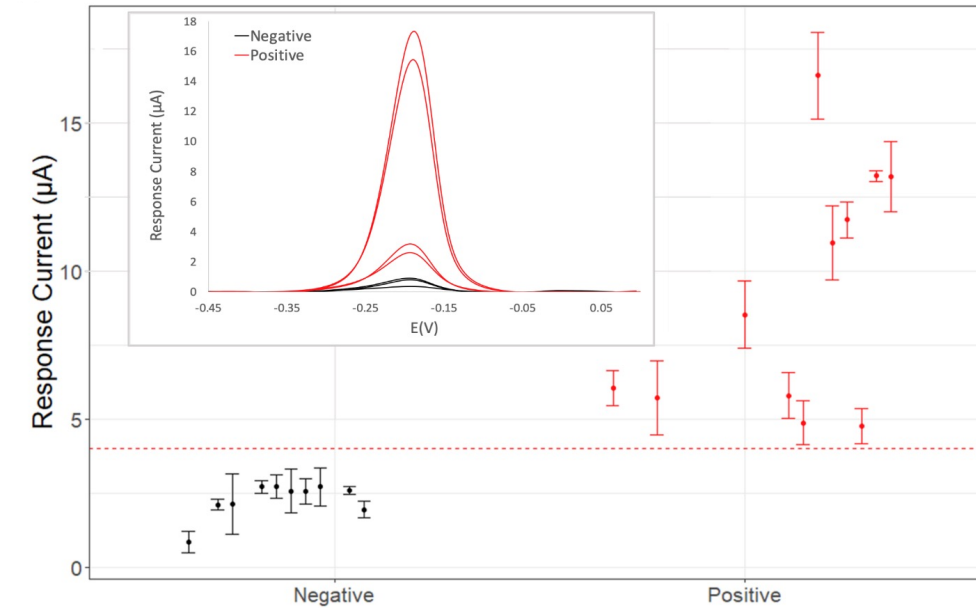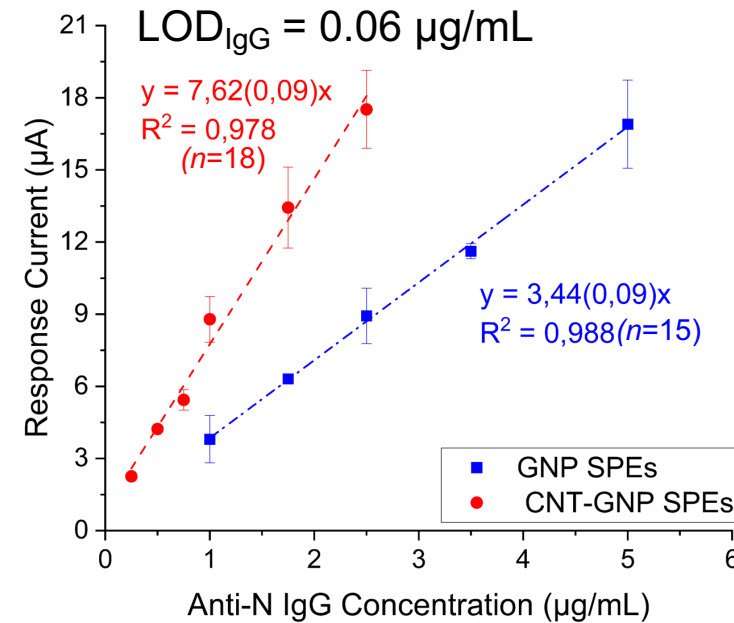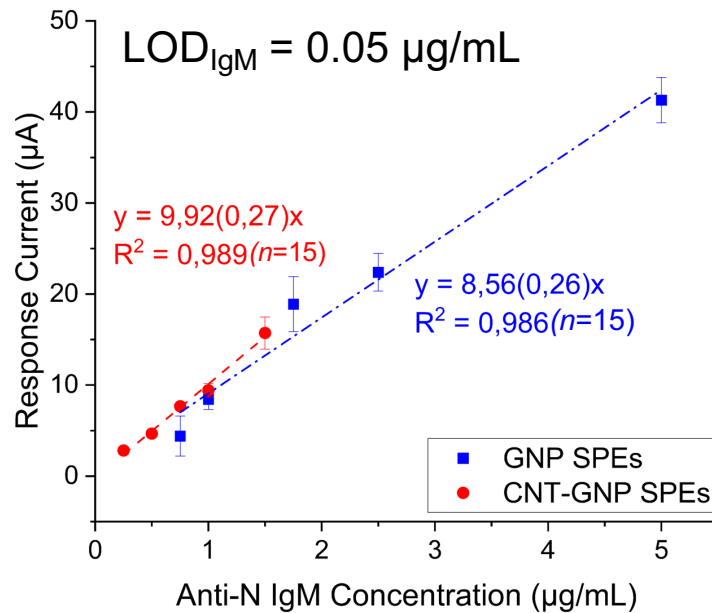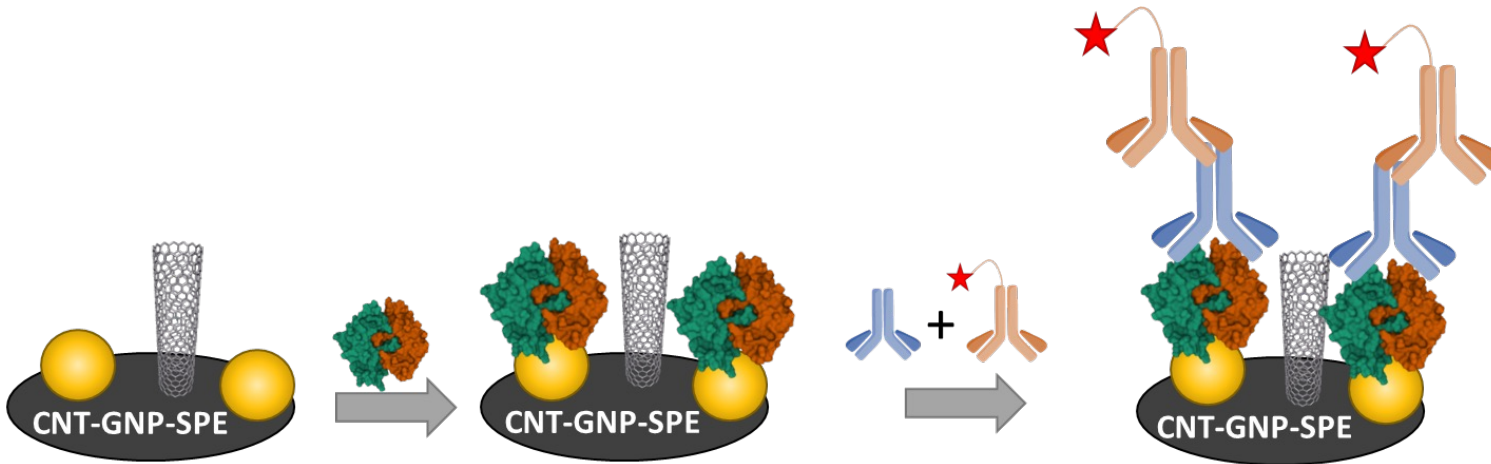
151 points/scan

Smart Immunosensors for Point-of-Care Serological Tests Aimed at Assessing Natural or Vaccine-Induced SARS-CoV-2 Immunity

Simone Fortunati [1], Marco Giannetto [1,*], Chiara Giliberti [1], Angelo Bolchi [1], Davide Ferrari [1], Massimo Locatelli [2], Valentina Bianchi [3], Andrea Boni [3], Ilaria De Munari [3] and Maria Careri [1,*]

In collaboration with Dr. Massimo Locatelli from IRCCS San Raffaele Hospital, Milan

OSPEDALE SAN RAFFAELE
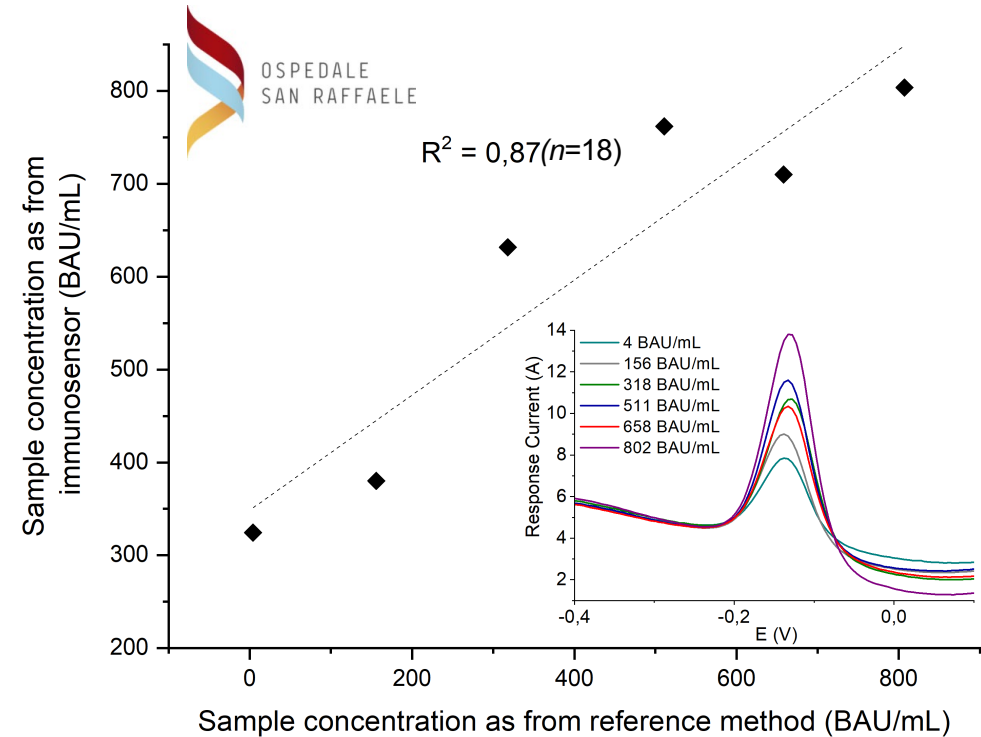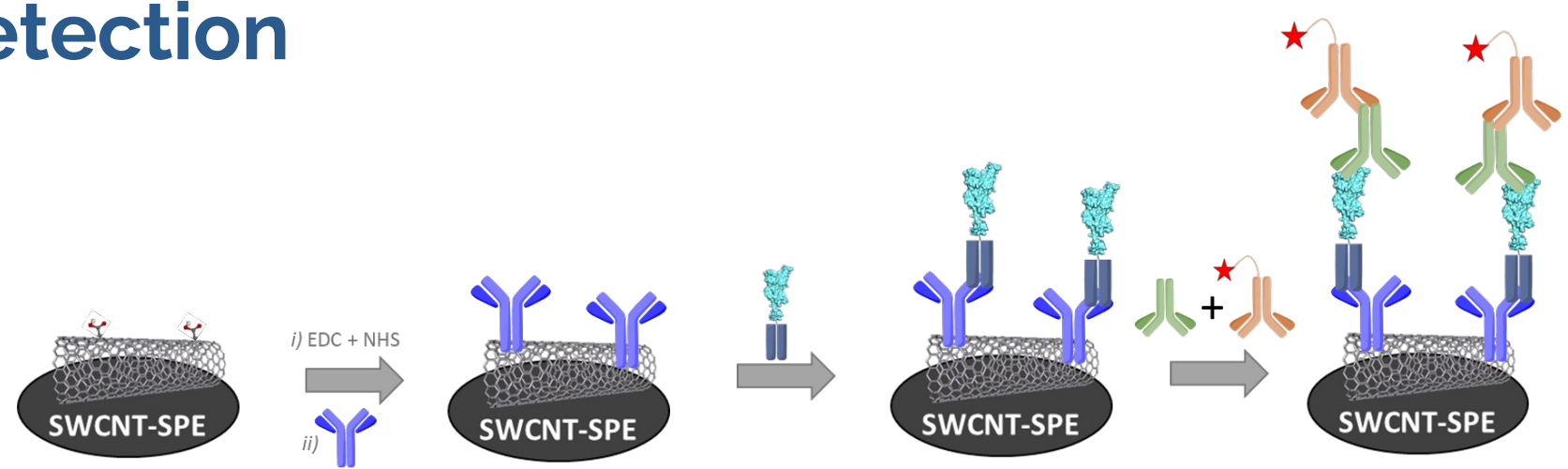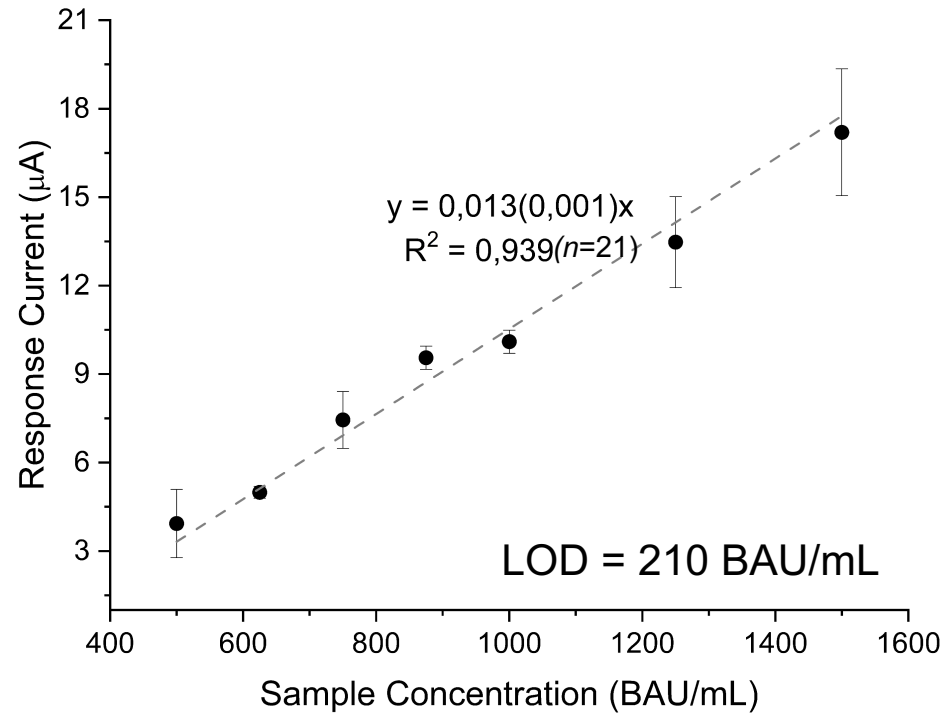
Anti-Nc antibody

Anti-Spike antibody

Nucleocapsid protein (Nc)

S1 domain of Spike protein

Point-of-Care

Personal Computer

cloud based portable potenstiostat

COTS-hw   SoC   bar code scan

AFE   DAC   FW   ADC

home

Smartphone/Tablet

Anti-nucleocapsid detection

LOD$_{IgM}$ = 0.05 µg/mL

y = 9,92(0,27)x
R^2 = 0,989 (n=15)

y = 8,56(0,26)x
R^2 = 0,986 (n=15)

- GNP SPEs
- CNT-GNP SPEs

Anti-N IgM Concentration (µg/mL)

LOD$_{IgG}$ = 0.06 µg/mL

y = 7,62(0,09)x
R^2 = 0,978
(n=18)

y = 3,44(0,09)x
R^2 = 0,988 (n=15)

- GNP SPEs
- CNT-GNP SPEs

Anti-N IgG Concentration (µg/mL)

- 10 negative serum samples
- 11 positive serum samples

Anti-Spike detection

LOD = 210 BAU/mL

y = 0,013(0,001)x
$R^2 = 0,939 (n=21)$

$R^2 = 0,87 (n=18)$
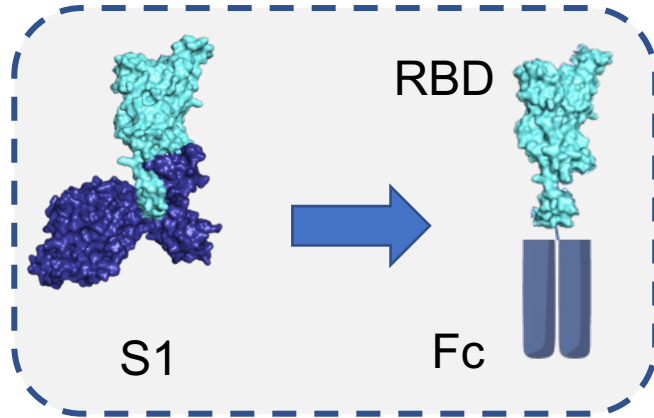
Reference method: *Roche Chemiluminescence immunoassay*