# PLAQCHEK

# Lp-PLA2 Immunosensor for Cardiovascular Risk Assessment

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# Motivation

Heart disease is the #1 cause of death worldwide, with 20.5 million deaths occurring in 2021

Current cardiovascular risk assessments have limited accessibility

# Problem Background

Lp-PLA2 is an enzyme involved in the development of atherosclerosis

Multiple studies identify the enzyme as a biomarker for cardiovascular health

# Problem Definition

To grant readily available cardiovascular assessment by developing a cheap and accessible device that estimates a user's CAD risk level, enabling early clinical intervention.

# Primary Customer Requirements

01

## Detect Lp-PLA2

02

## Limit of Quantization

LoQ ≤ ±2 ng/mL

03

## Detection Range

0 ng/mL to 300 ng/mL

04

## Response Time

End-to end response time of 30 minutes

# Secondary Customer Requirements

01

## Improved Response Time

End-to end response time decreased to 20 minutes

02

## Mobile App

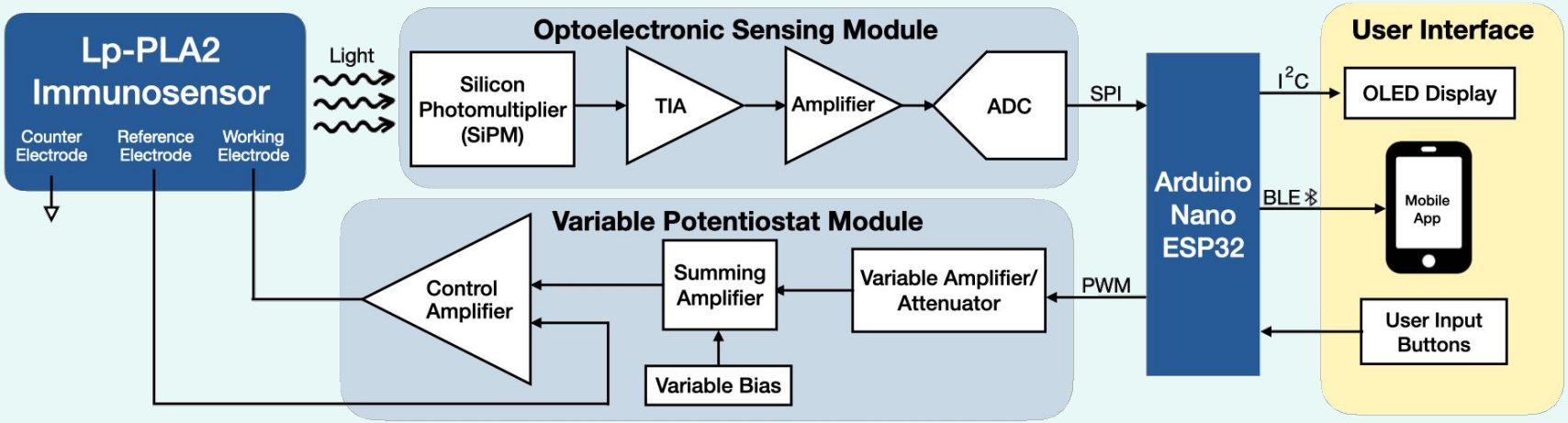
Implement mobile app, with ≤ 500 ms latency

03

## Lightweight and Portable

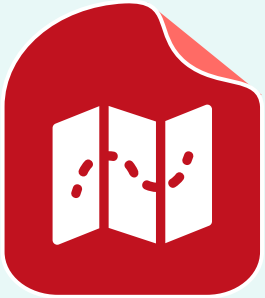
# Design Approach

- Obtain blood sample from user
- Apply sample to immunosensor that will affect the ECL reaction
- Detect ECL reaction with SiPM



# Design Advantages

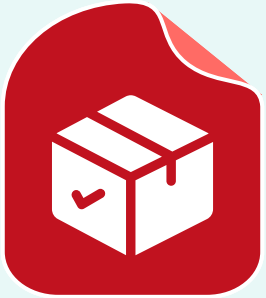
Portable



Accessible

Affordable

# Design Parameters



Total Volume of Sensor < 8000 $cm^3$

Easy to Use

Cost of Sensor < $200

# Trade-offs

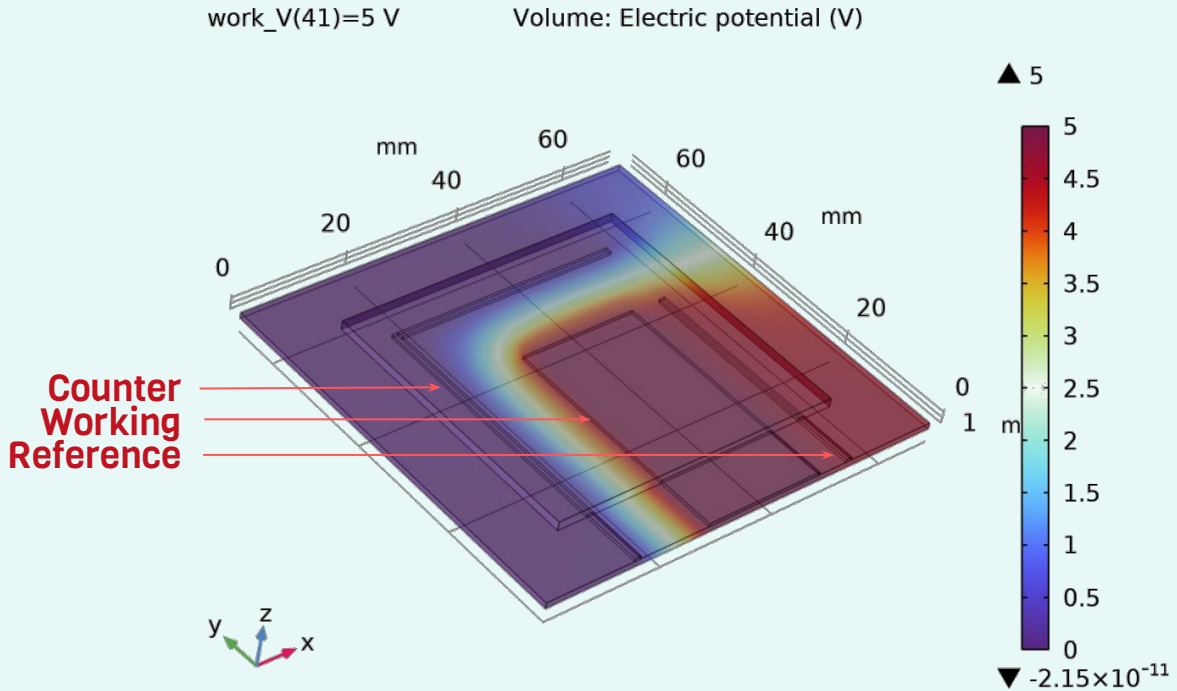
↑ Affordability
Portability

↓ Accuracy

↑ Non-invasiveness

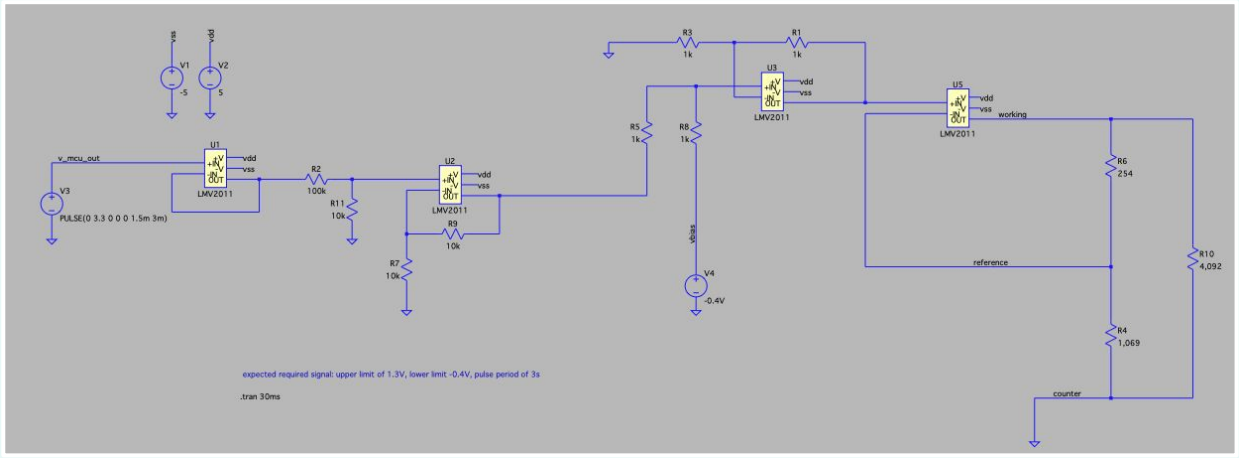
↓ Blood Volume

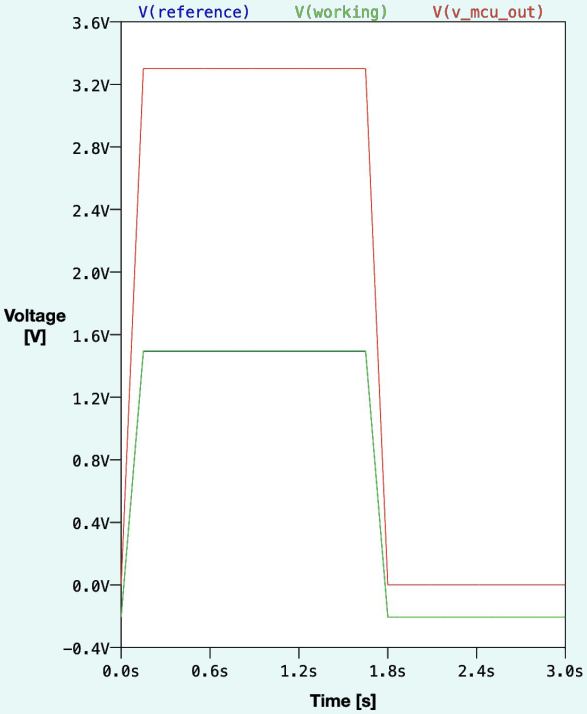
# Design Verification Data




COMSOL Simulation for Electrode Placement

# Design Verification Data




LTspice Simulation for Potentiostat

# Prototype Construction

Fabricating Sensor

Enclosure Prototyping

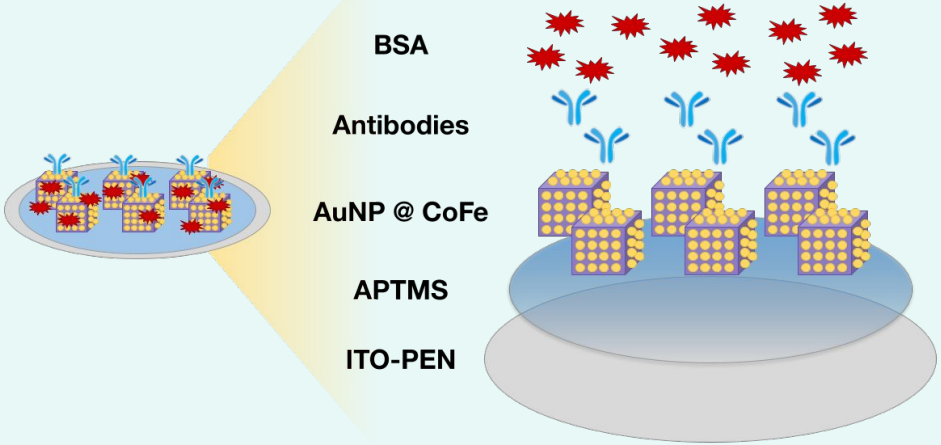
Antibody Immobilization

Electronics Calibration

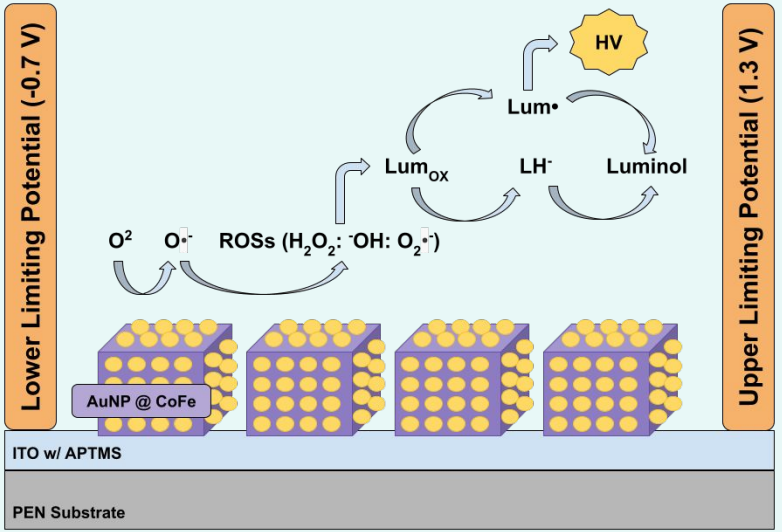
PCB Design & Assembly

System Integration

# Prototype Construction - Sensor Fabrication

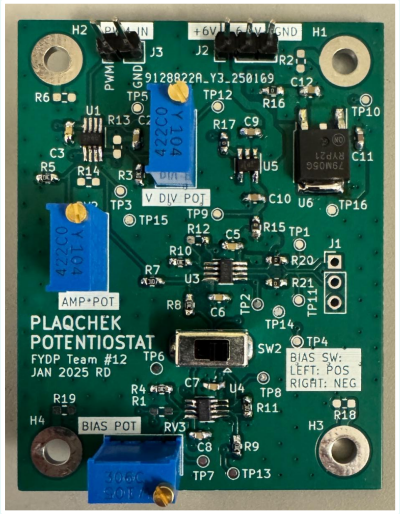



Sensor Fabrication



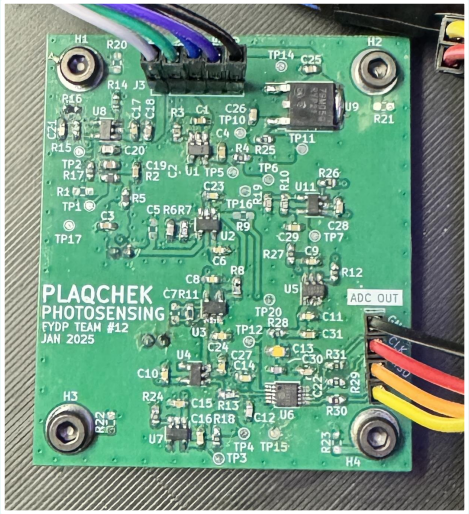

Reaction Mechanism

# Prototype Construction - Electronics



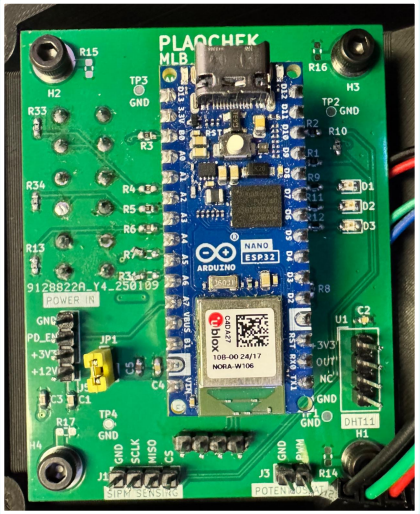

## Potentiostat

- Variable analog potentiostat
- Modifies PWM signal
- Drives 3-electrode system



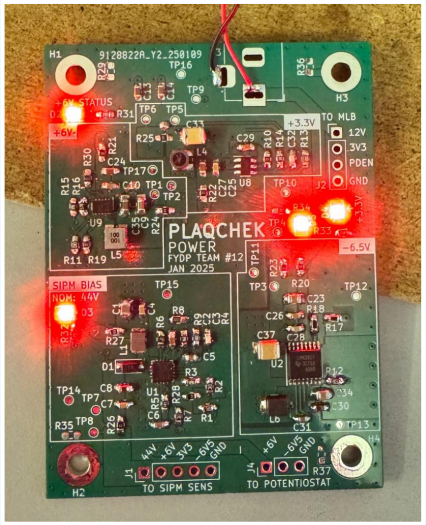

## Optoelectronic Sensing

- Signal processing
- SiPM, TIA, amplifier, and ADC for immunosensor readout




## Main Logic Board

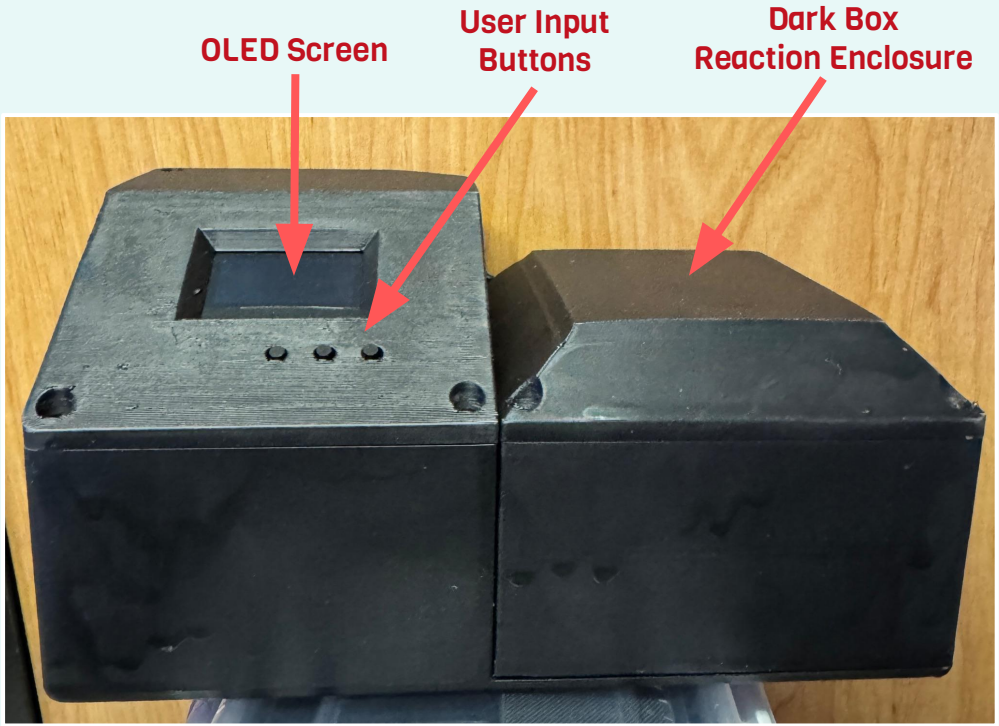
- Applies calibration curve
- Bluetooth connection
- OLED screen and buttons

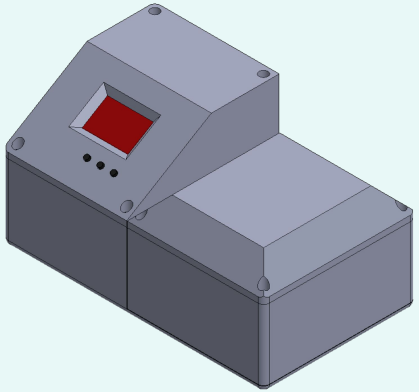


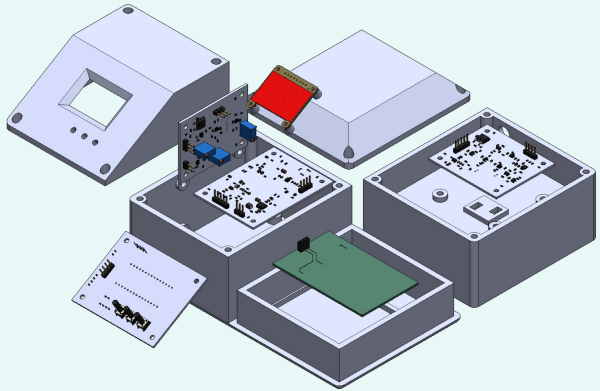

## Power Distribution

- 12 V input
- Switching regulators for system voltage regulation

# Prototype Construction - Enclosure

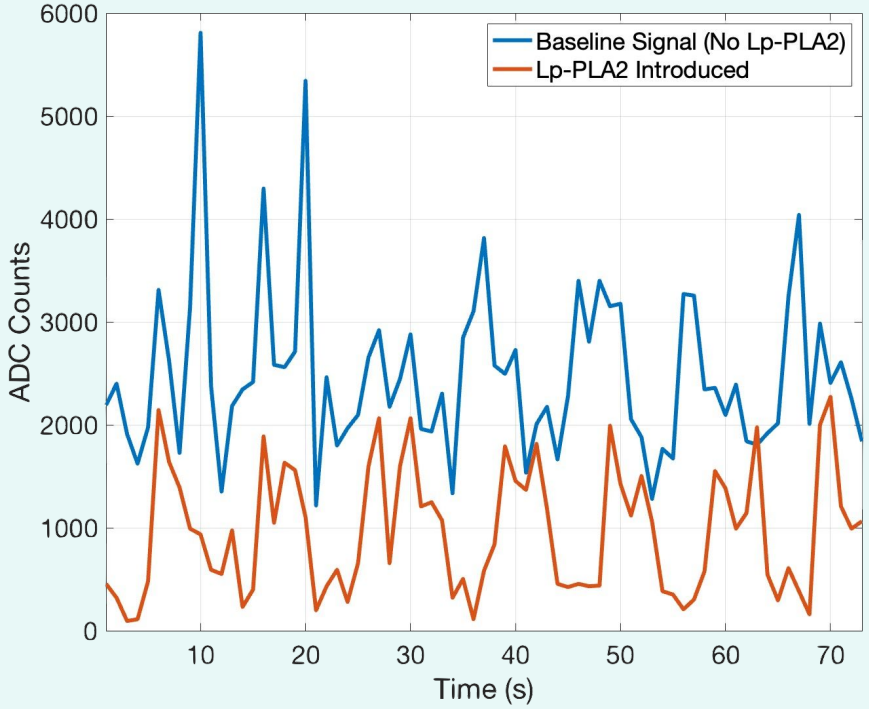


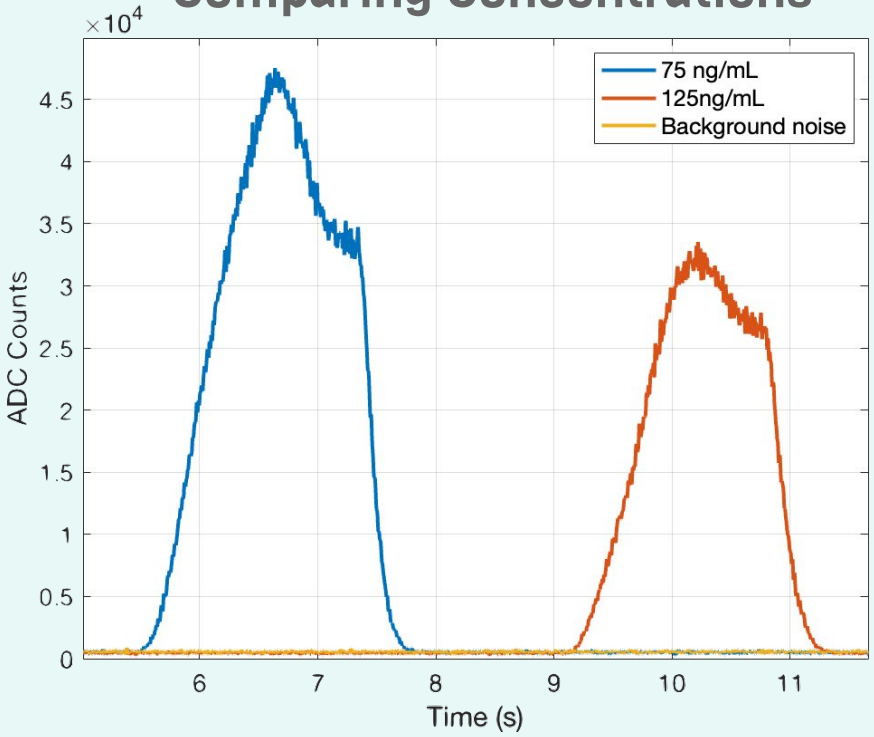


# Test Results

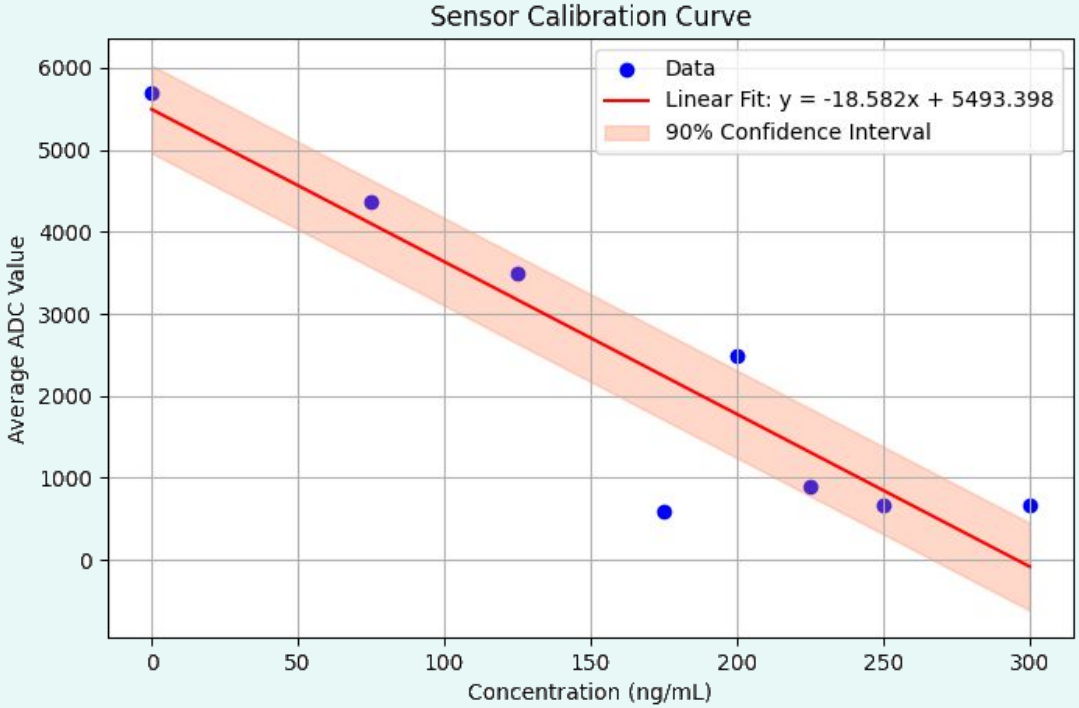
## Preliminary Results




## Comparing Concentrations



# Test Results & Discussion




$$y = -0.0538x + 295.63$$

X = Average of the first 2000 ADC values minus the dark reference average

Y = Concentration of Lp/PLA2 in ng/ml

# Cost Breakdown

## Cost of Sensor

| | |
|---|---|
| Electronic Components | $120.00 |
| PCBs | $30.00 |
| Enclosure | $17.50 |
| Total | **$167.50** |

## Cost of Cartridge

| | |
|---|---|
| ITO Covered PEN | $1.14 |
| Chemicals | $0.84 |
| Antibodies | <$0.01 |
| Total | **$1.98** |

# Conclusions

- Device can detect presence of Lp-PLA2 in a sample
- Major customer requirements were fulfilled

- [x] **Detect Lp-PLA2**
- [-] **Limit of Quantization**
- [x] **Detection Range**
- [x] **Quick Response Time**
- [x] **Lightweight and Portable**
- [x] **Mobile App**

# Research Resources

Wang, L., Liu, Y., Yan, J., Li, H., & Tu, Y., “Novel Electrochemiluminescent Immunosensor Using Dual Amplified Signals from a CoFe Prussian Blue Analogue and Au Nanoparticle for the Detection of Lp-PLA2”

Xu, R., Shen, Z., Xiang, Y., Huang, J., Wang, G., Yang, F., Sun, J., Han, J., Liu, W., Duan, X., Zhang, L., Zhao, J., Sun, X., & Guo, Y., “Portable electrochemiluminescence detection system based on silicon photomultiplier single photon detector and aptasensor for the detection of tetracycline in milk. Biosensors and Bioelectronics”

Y., “Portable electrochemiluminescence detection system based on silicon photomultiplier single photon detector and aptasensor for the detection of tetracycline in milk”

# Thanks!

## Do you have any questions?

**SPECIAL THANKS TO:**
Dr. John Saad - Project Consultant
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Dr. Asif Abdullah Khan - COMSOL Advisor

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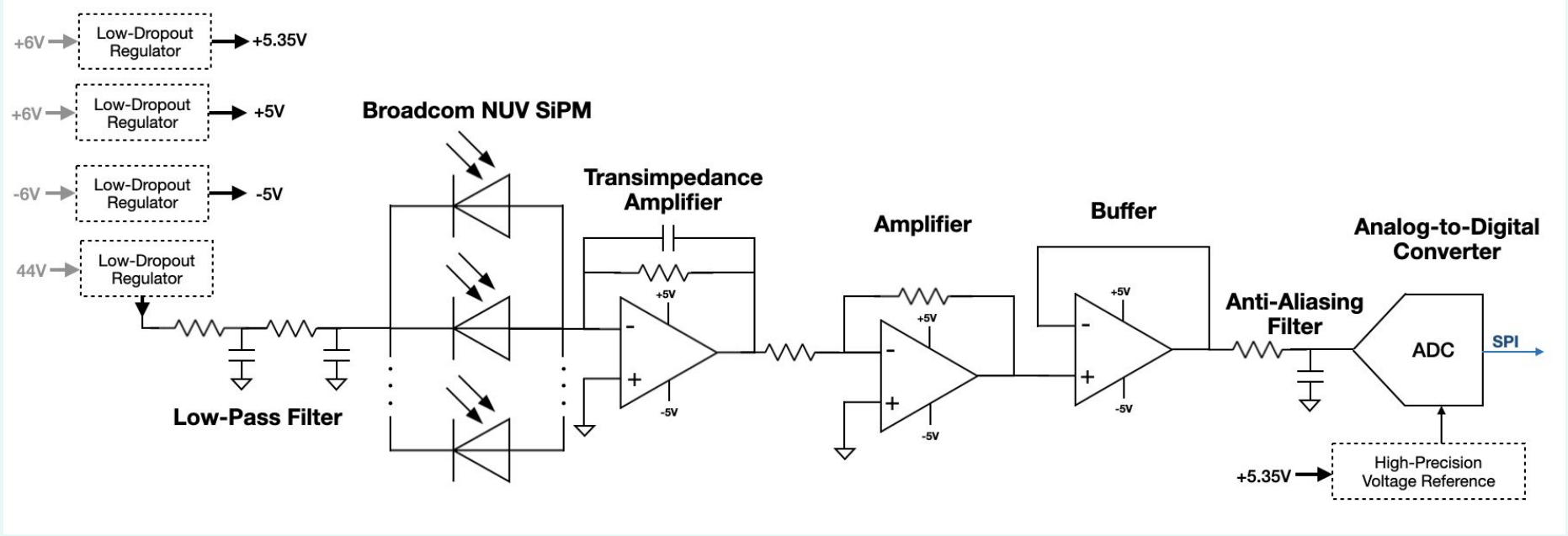
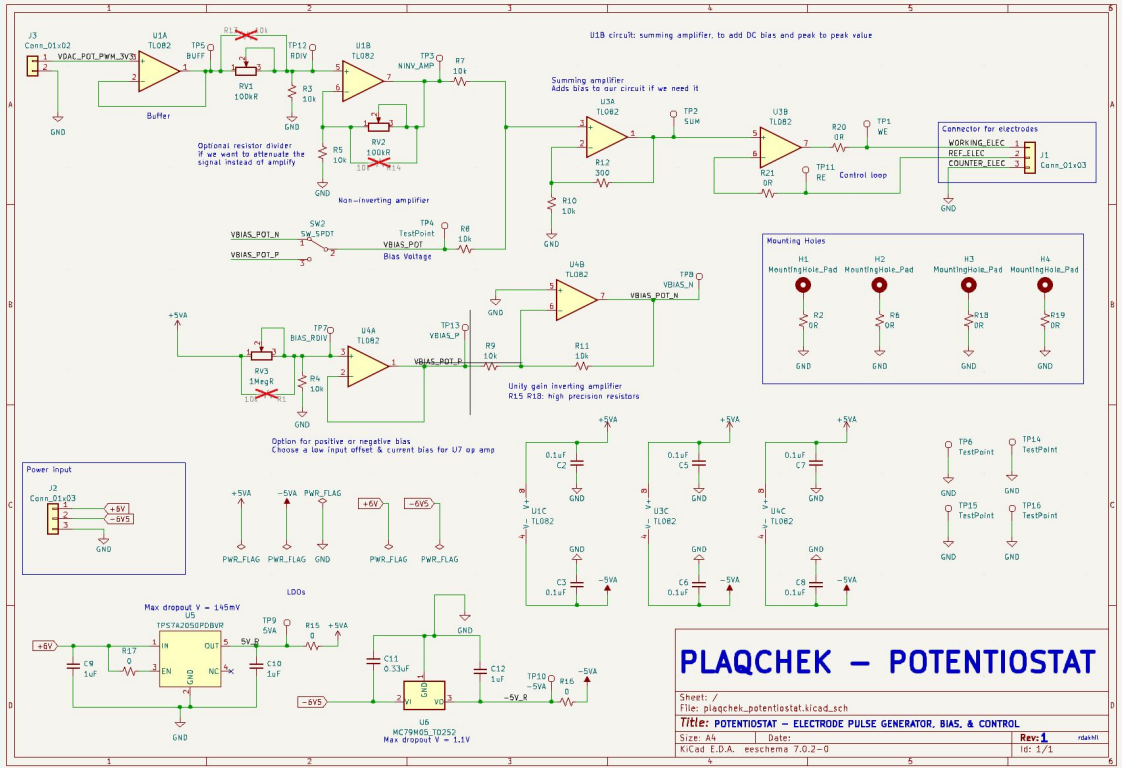
# Appendix A - Electronics

## Optoelectronic Module Schematic



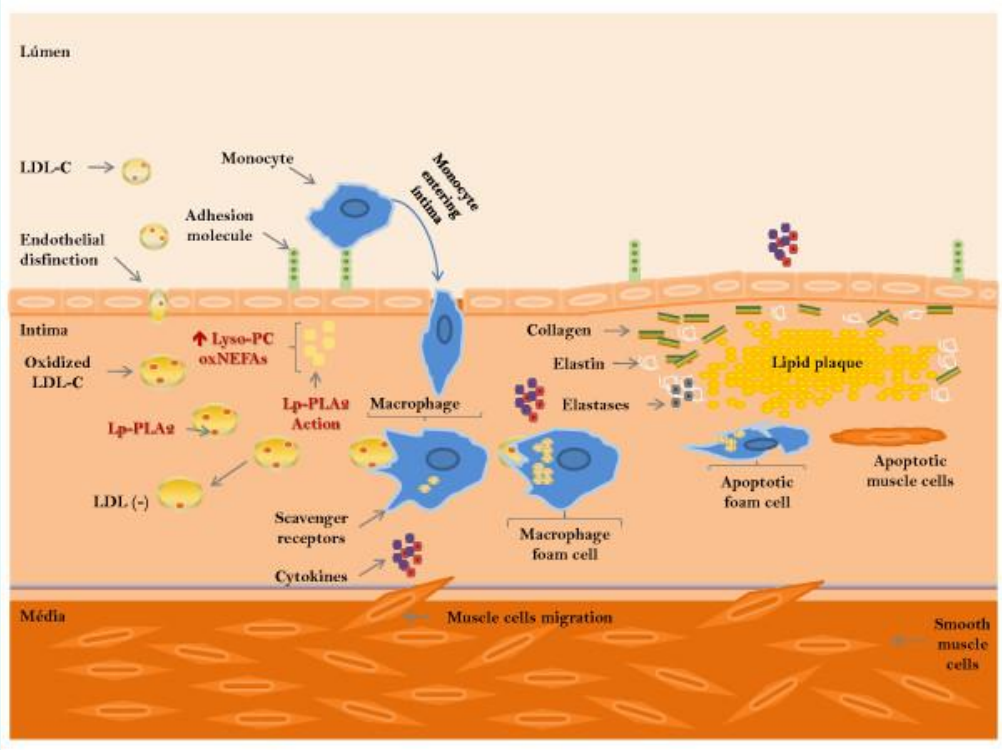
# Appendix A - Electronics

## Potentiostat Module Schematic



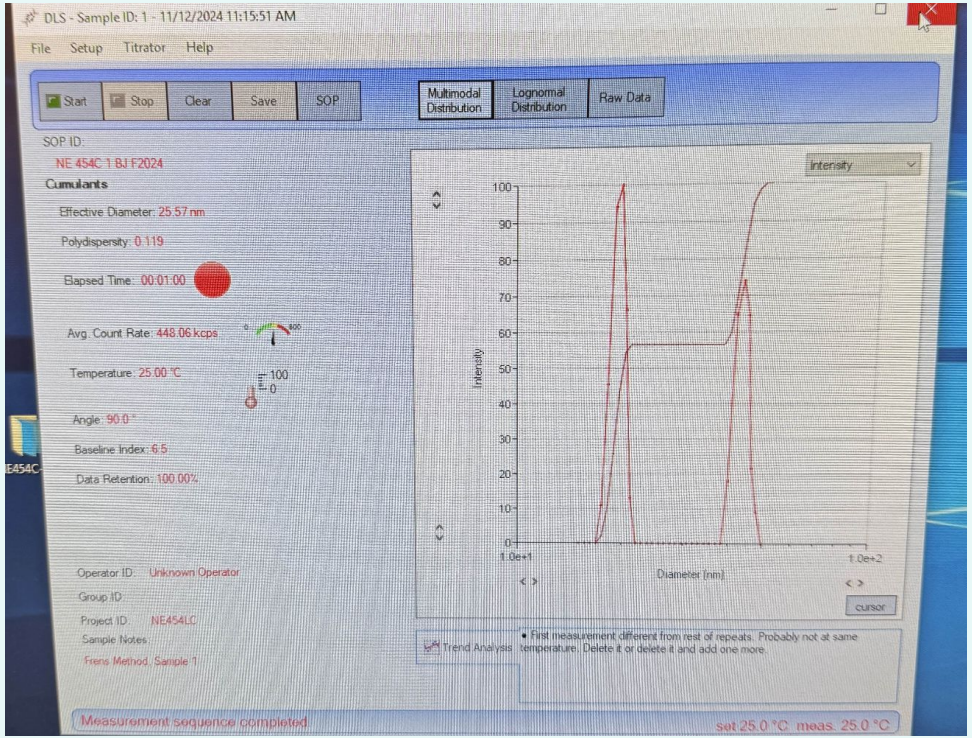
# Appendix B - Biomechanisms

## Plaque Buildup Mechanism



# Appendix C - Material Characterization

## DLS Results of Gold Nanoparticles



# Appendix C - Material Characterization

## SEM Results of PEN with coating