



Mass General Brigham

An opto-chemical wearable end-tidal CO₂ monitoring device for emergent care

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Disclosure

Nianyu Jiang, Ph.D. has no conflicts to report.

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Motivation

CAPNOGRAPHY: A CRITICAL NEED FOR BATTLEFIELD CARE



1. BATTLEFIELD NEED: RESPIRATORY FAILURE IS A LEADING PREVENTABLE CAUSE OF COMBAT MORTALITY



SCALE OF NEED

Tens of thousands of U.S. service members require advanced respiratory support annually in deployed and evacuation settings.



Airway and respiratory compromise are **leading preventable causes of combat mortality.**



Early detection of ventilation failure via capnography is **recommended throughout prolonged field care, evacuation, and transport.**

SUPPORTING LITERATURE

- [1] Committee on Tactical Combat Casualty Care (CoTCCC), Prolonged Casualty Care Guidelines.
- [2] Butler FK et al. Tactical Combat Casualty Care, J Trauma Acute Care Surg., 2021.



2. CURRENT CAPNOGRAPHY OPTIONS IN FIELD CARE

Portable sidestream capnographs are primarily used after endotracheal intubation in field care and field hospitals.

Monitoring of spontaneously breathing casualties remains limited.



MOST COMMON USE: FIELD CARE & FIELD HOSPITALS

CURRENT DEVICES



- Sidestream infrared (NDIR) analyzers
- Require sampling tube or airway adapter, bulky, and not optimized for continuous wearable use



Motivation – A lightweight capnography device

THE NEED:
LIGHTWEIGHT, WEARABLE, RELIABLE
CAPNOGRAPHY FOR EVERY POINT OF CARE



- ✓ For all respiratory patients (intubated & non-intubated)
- ✓ Wearable, wireless, and unobtrusive
- ✓ Designed for prolonged field care, transport, and austere environments

Coin-size Capnography for ICU Gas Mask

Need: Lightweight, mask-integrated capnography enables non-invasive, continuous CO₂ monitoring in prolonged field care, en route transport, and field hospital settings.

A) Prolonged Field Care Settings



Lightweight & compact for extended use in resource-limited environments.

B) En Route Care Settings



Reliable, continuous CO₂ monitoring during movement and evacuation.

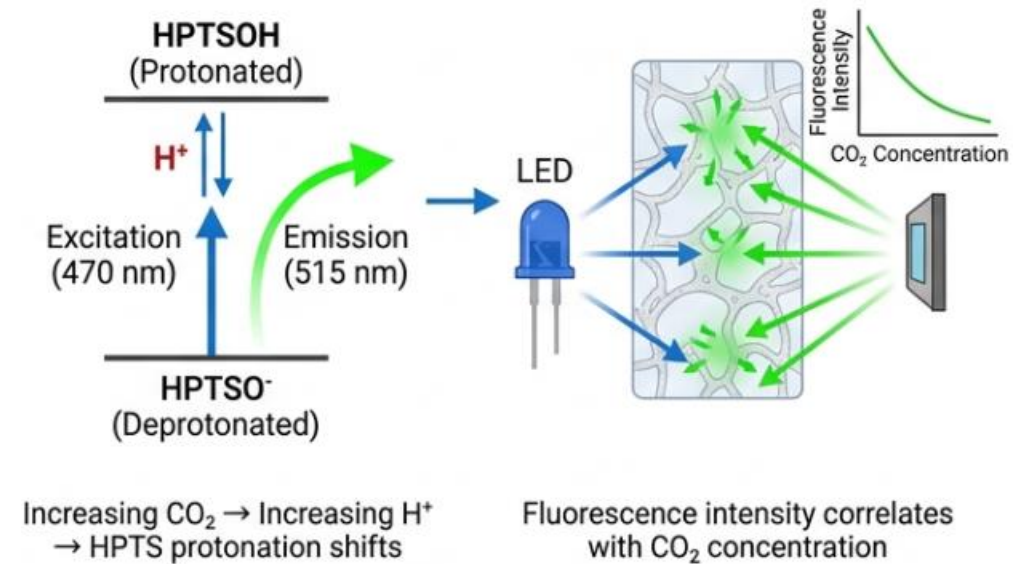
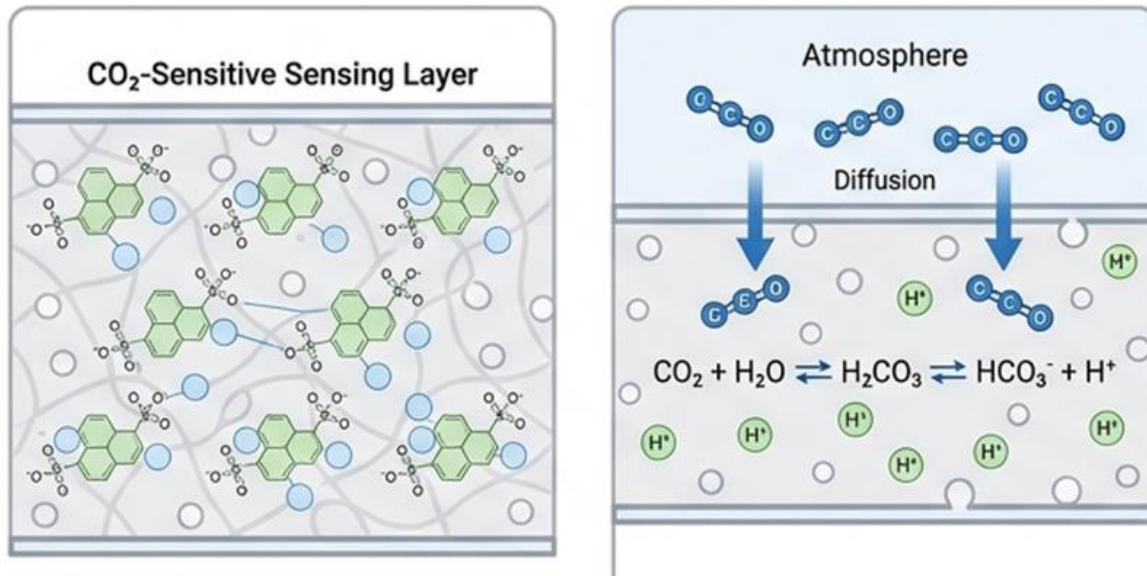
C) Field Hospital Settings



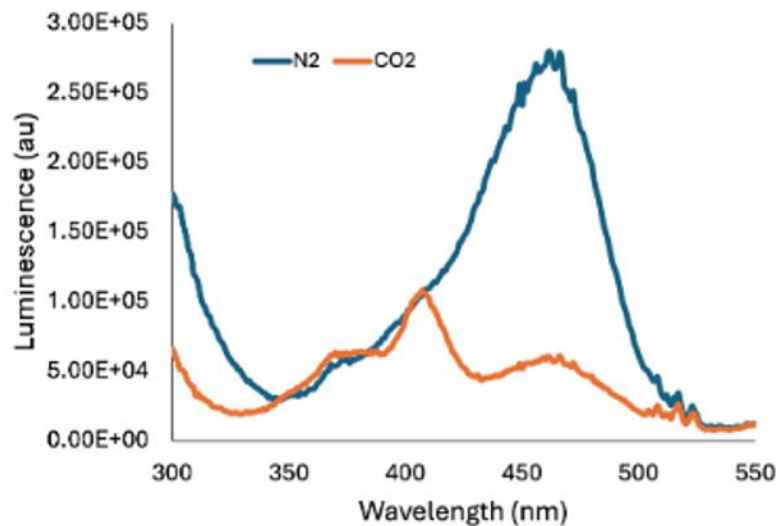
Seamless integration into field hospitals without adding bulk or complexity.

CO₂ sensitive opto-chemical material

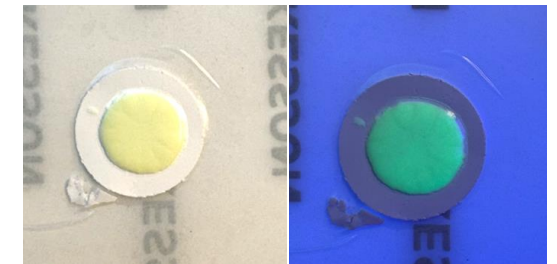
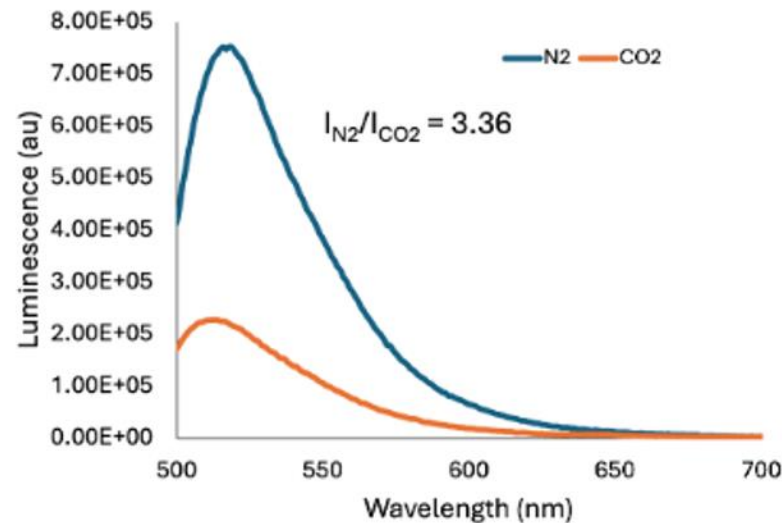
- 8-hydroxy-1,3,6-pyrenetrisulfonic acid trisodium salt (HPTS)
- tetraoctylammonium hydroxide (TOAOH)
- P(HEA-r-tBA)-b-PBA-b-P(HEA-r-tBA) triblock copolymer (ABACP)



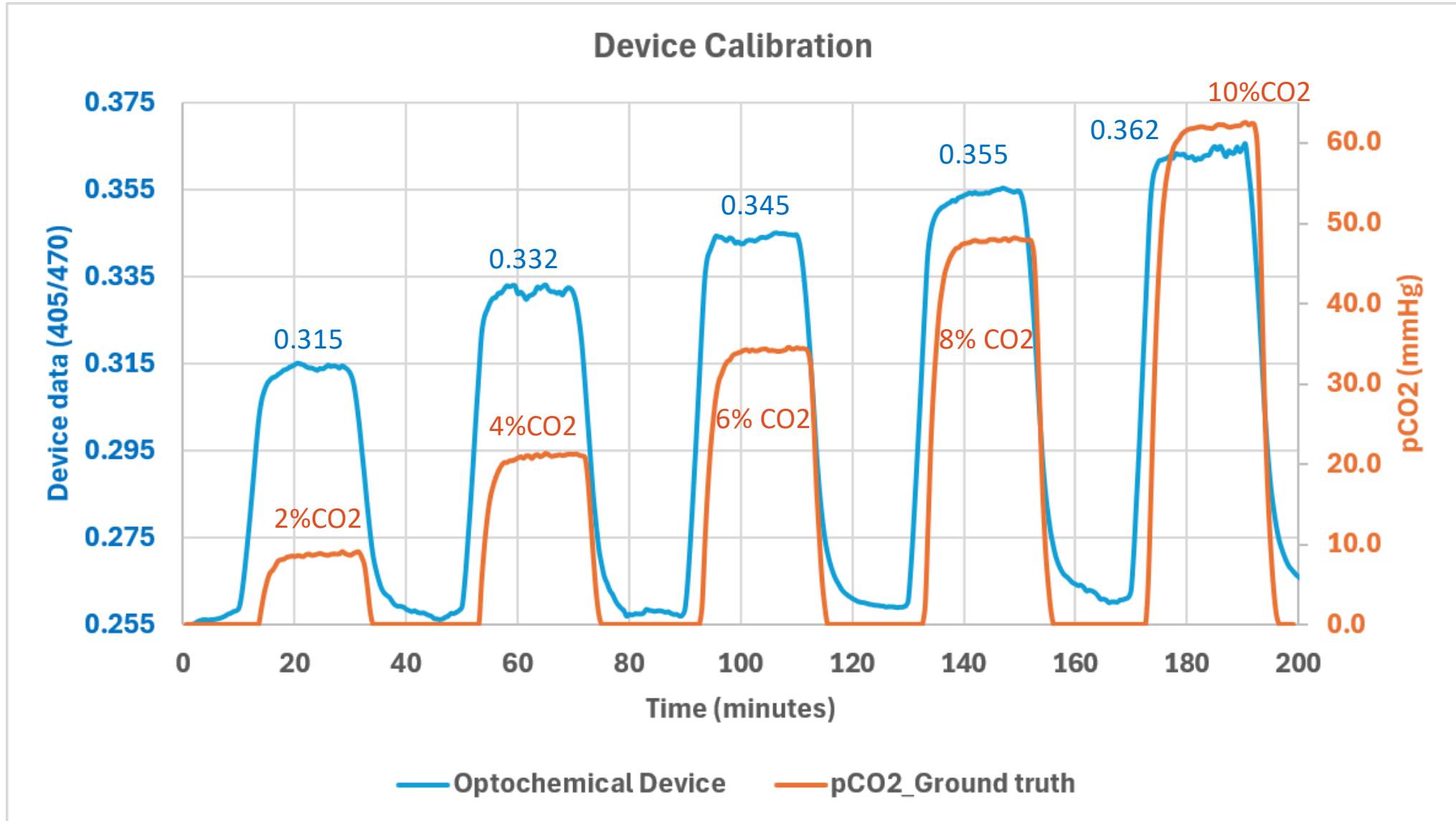
Spectrometer data **HPTS-ABABCP Excitation**



HPTS-ABABCP Emission



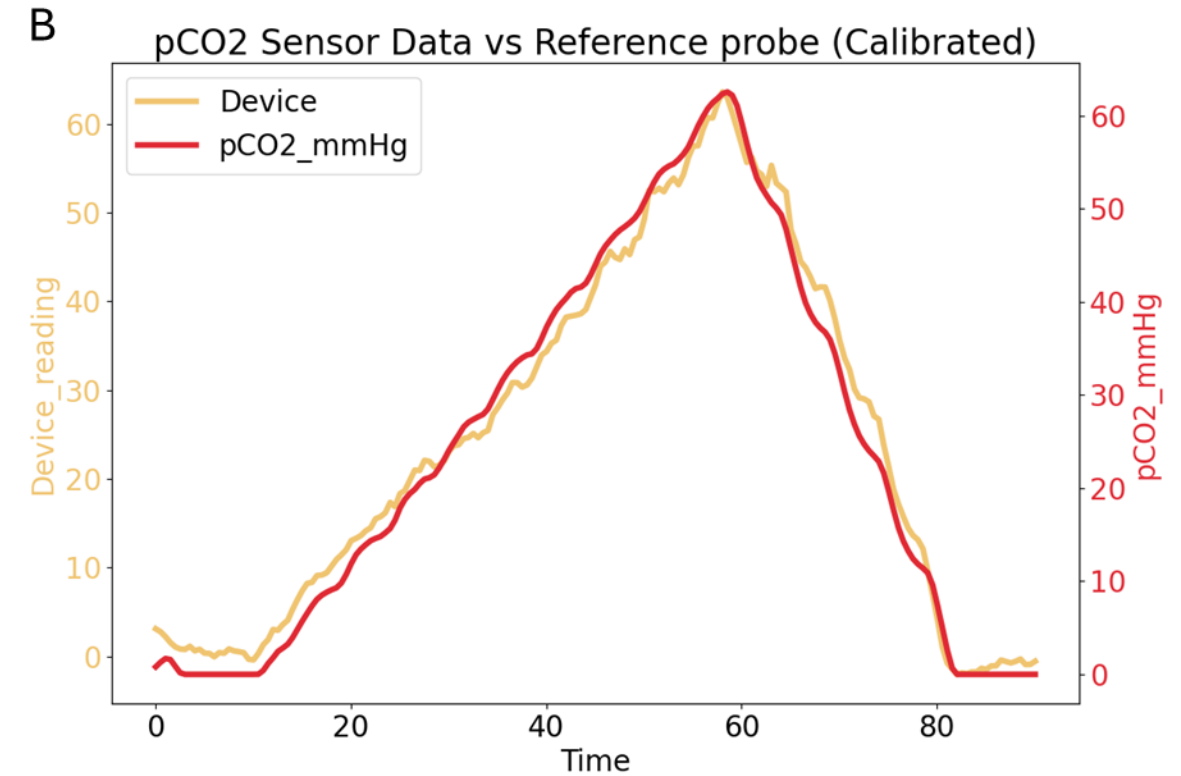
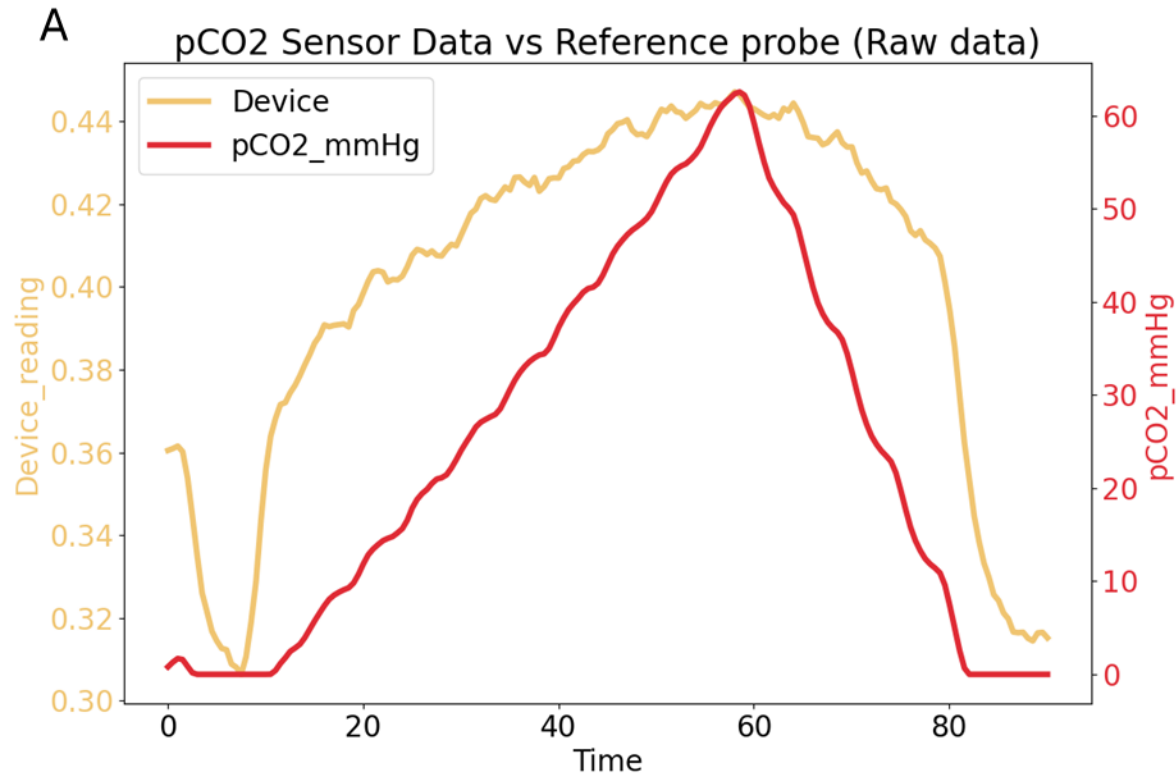
CO₂ responsive opto-chemical material



CO₂ responsive opto-chemical material

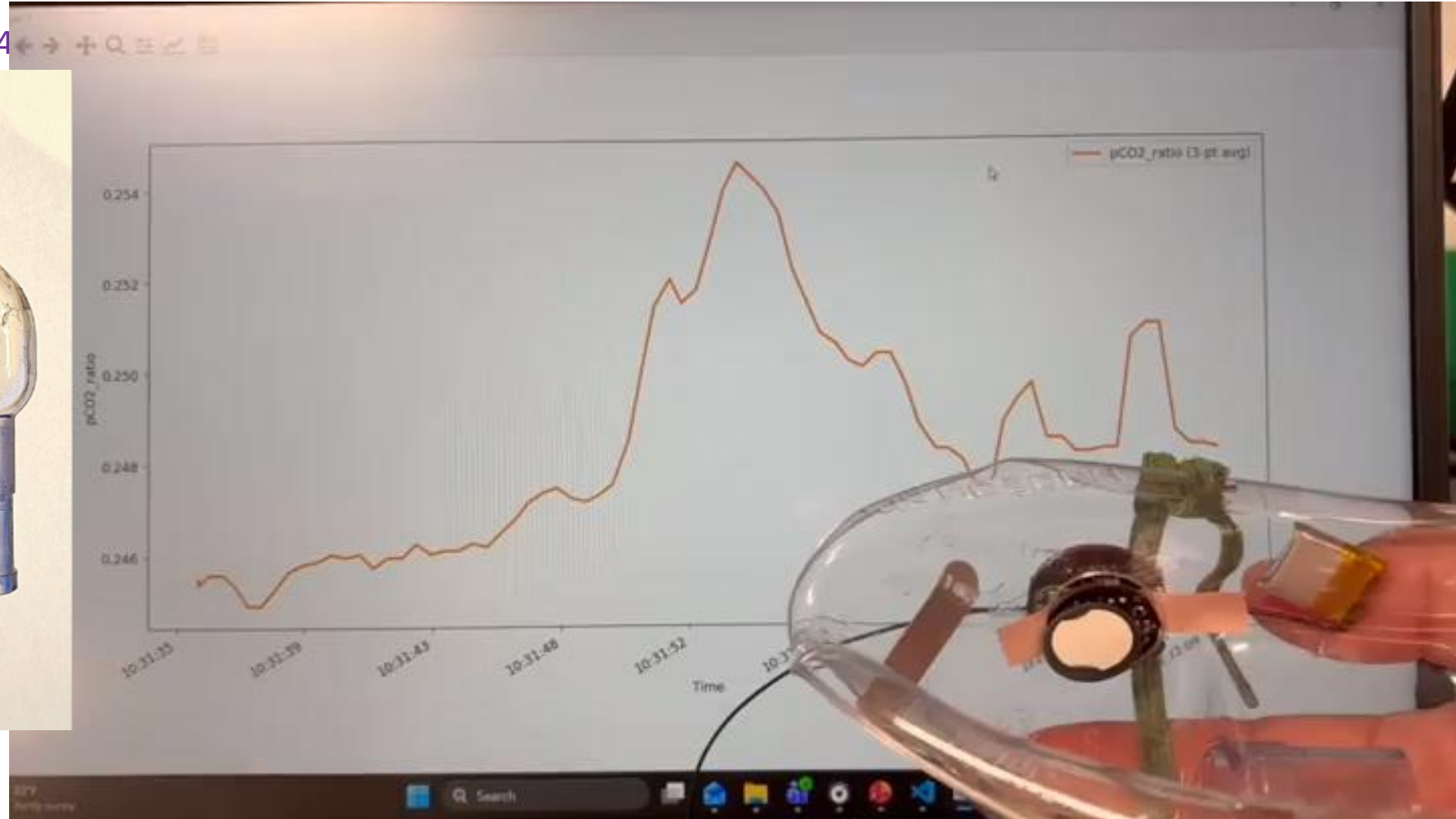
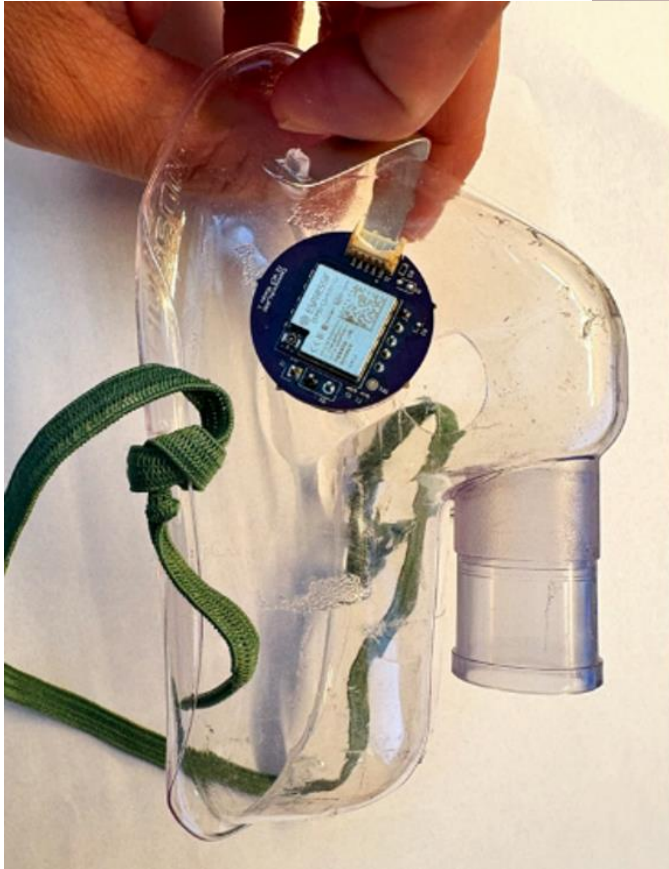
$$pCO_2 \text{ (mmHg)} = X_2 \frac{\frac{x_{405} - x_0}{x_{470} - x_1} - x_3}{x_T - x_4} - x_5$$

Use linear regression to get X[6,1]



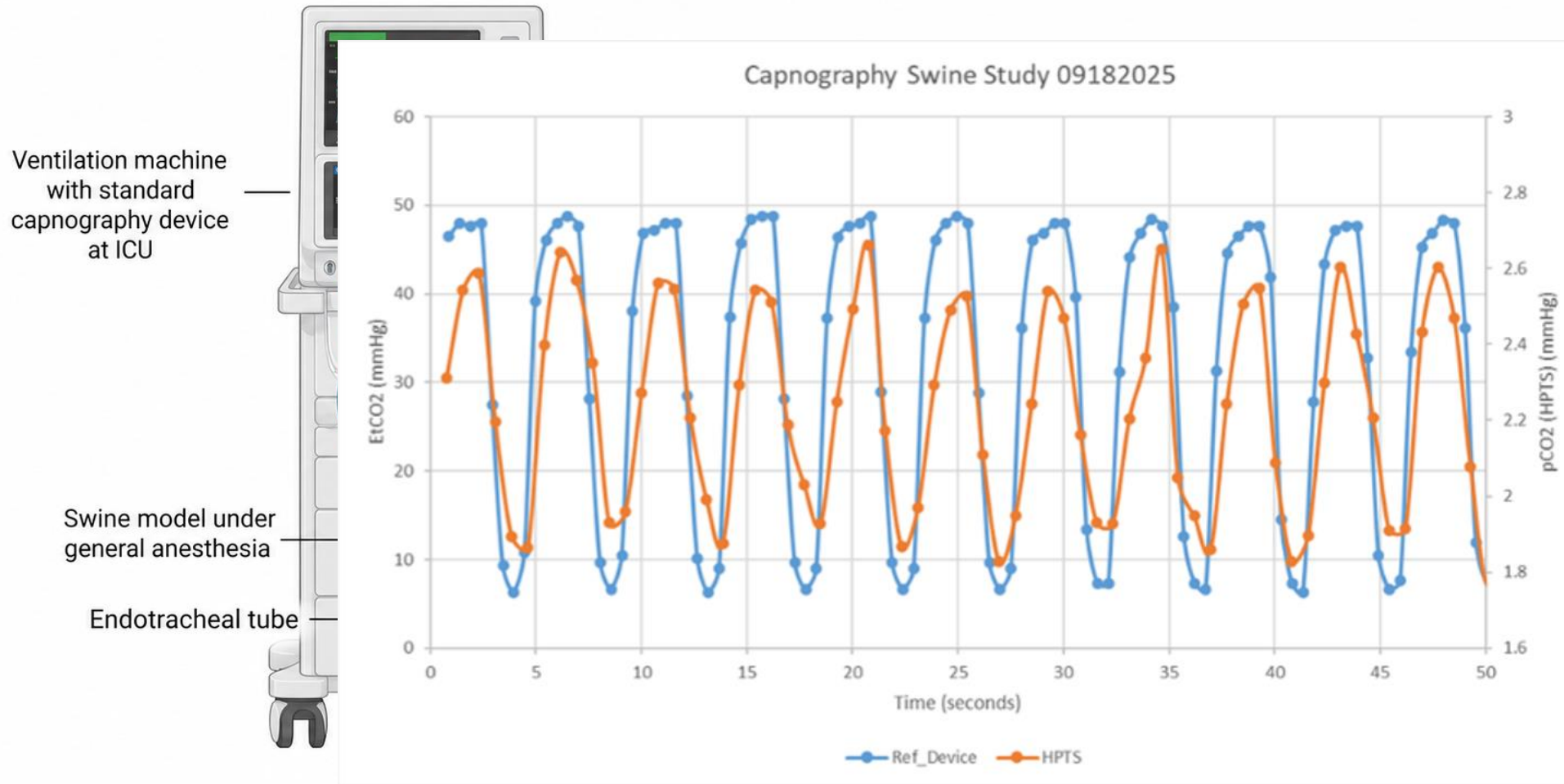
Electronic readout

470nm LED



Cascales JP, Li X, Roussakis E, Evans CL. A Patient-Ready Wearable Transcutaneous CO₂ Sensor. *Biosensors (Basel)*. 2022 May 13;12(5):333. doi: 10.3390/bios12050333. PMID: 35624634; PMCID: PMC9138690.

Animal tests

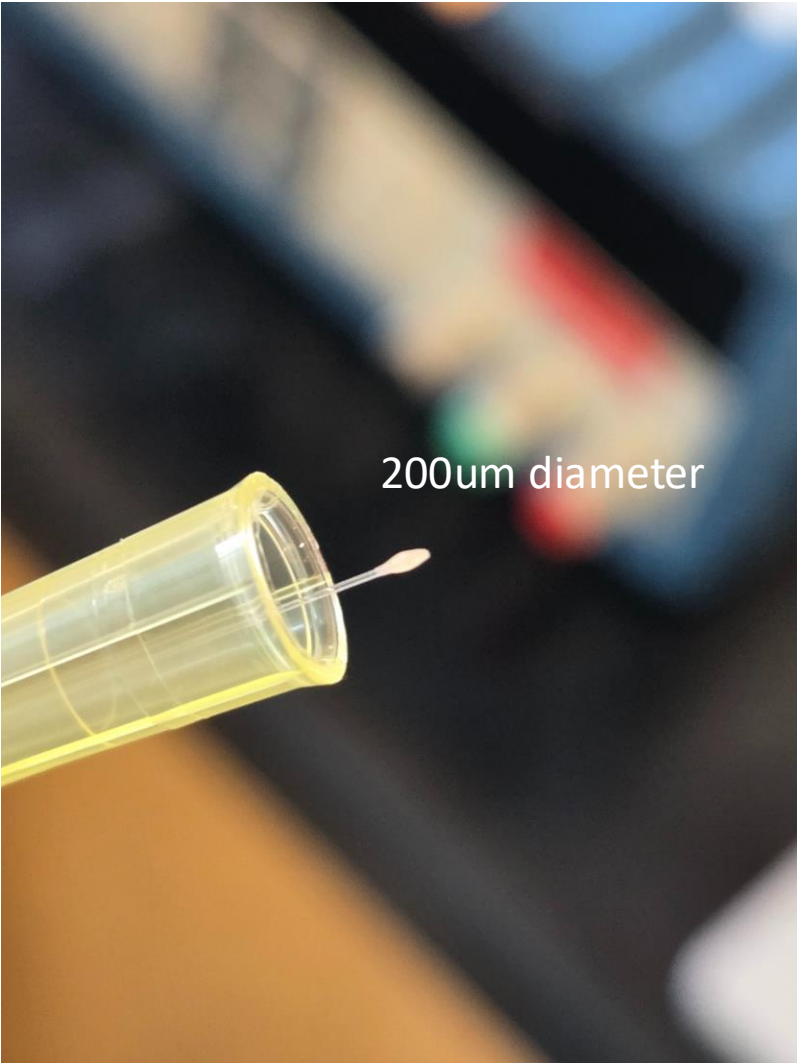


Reference:
6 – 48 mmHg

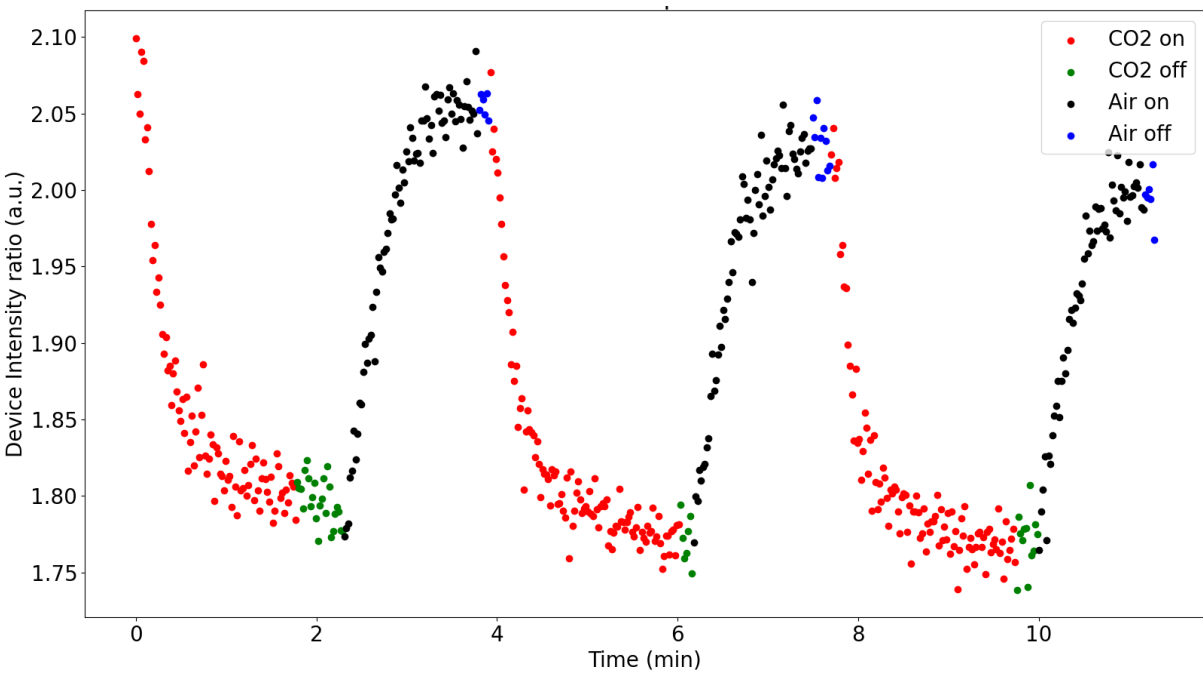
Sensor:
1.8 – 2.6 mmHg

Main reason:
Side stream

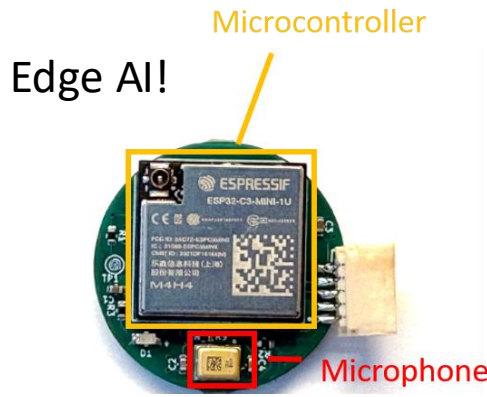
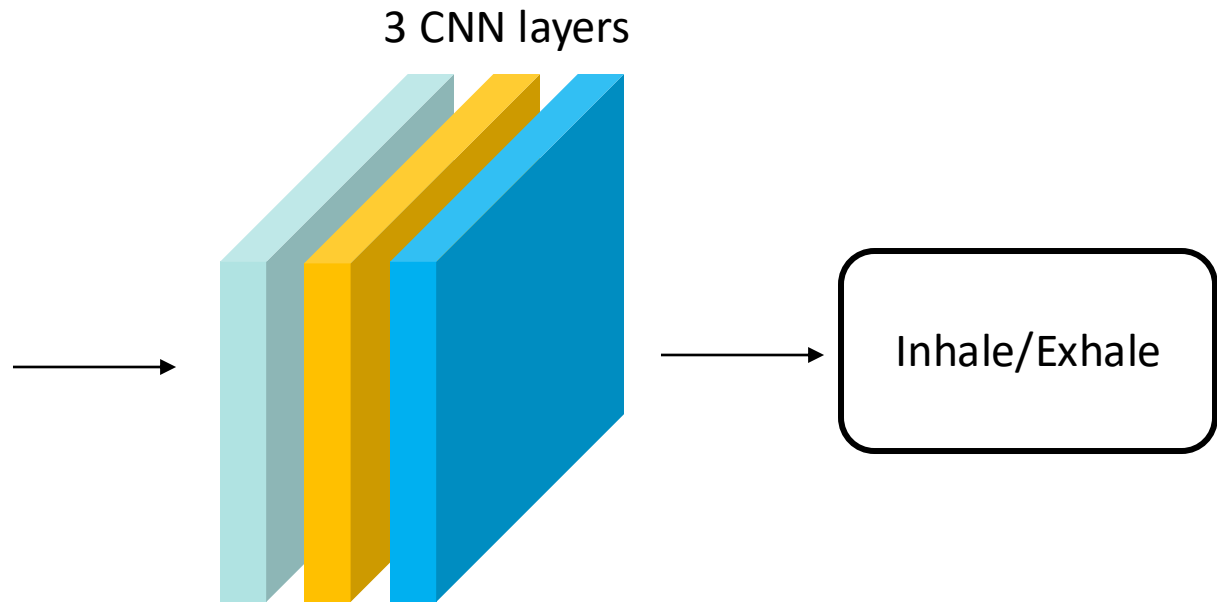
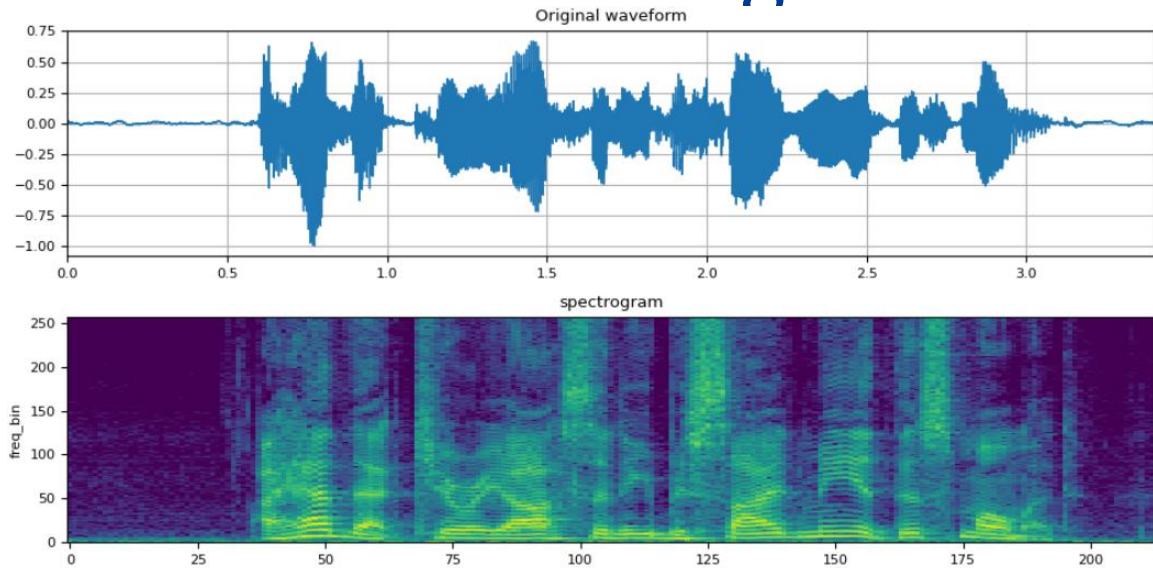
Future work – Nasal cannula



Intensity response to PCO₂



ML for breath recognition

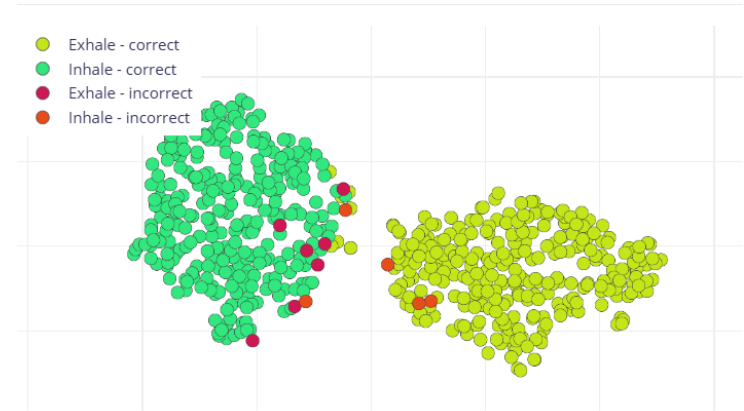


Last training performance (validation set)



Confusion matrix (validation set)

	EXHALE	INHALE
EXHALE	90.6%	9.4%
INHALE	7.1%	92.9%
F1 SCORE	0.92	0.91



On-device performance





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