

HYPEngineers:

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Low-Cost
Controllable
Hypoxia Chamber
for Exploring Stem
Cell Behavior

Objective & Motivation

Design and build a low-cost hypoxia chamber for stem cell research.

- Stem cells naturally grow in a low-oxygen environment
- Simulating this environment during experiments allows:
 - Efficient cultivation of stem cells
 - Research regarding the effect of low-oxygen environments on the cells' development



Value Proposition

- Current commercially available hypoxia chambers are expensive
- The aim is to develop a simple, low-cost hypoxia chamber for stem cell research
- The chamber design and manufacturing plan will be included in a paper which will be published in an open access journal
- This will allow other researchers to utilize our technology and ideas

Budget

We are working with a budget of \$1000

Expense Items	Price	Expense Items	Price
Arduino Mega Equivalent	\$ 15.86	Epoxy	\$ 12.15
Oxygen Sensor	\$ 99.00	Tubing	\$ 10.00
O2 adapter board	\$ 7.94	3D -printing filament	\$ 25.50
Breadboard	\$ 8.59	Pre-made Container	\$ 21.99
Wires	\$ -	Logic converter	\$ 7.29
Input Solenoids x2	\$ 26.00	Power Supply	\$ 12.50
Exhaust Solenoid	\$ 13.00	O-rings	\$ -
Nitrogen	\$ 10.00	Through wall ethernet cable	\$ 10.05
CO2 Sensor	\$ 180	Ethernet adaptor	\$ 9.59
Through wall Tubing connector x2	\$ 15.30	Water Trays	\$ 10.00
Transistors	\$ 9.99	Misc.	\$ 100.00
Acrylic	\$ 19.98		
O-ring	\$ 7.29	Total:	\$ 644.95

Product Requirements

Functionality

Maintain oxygen levels between 1% and 21%
Maintain CO₂ levels at 5%

Durability

Maintain airtight hypoxic environment for 21 days
Work for multiple experiments

Working Environment

Function in temperature and humidity conditions in incubators

Logistics & Construction

Have a simple user interface
Simple and reproducible construction process
Low-cost

Physical Properties

Large enough to fit at least 4 well plates
Transparent
Fit inside incubator

Control System



Wiring

Exhaust Tubing

User Interface

Solenoids

Input tubing

Incubator

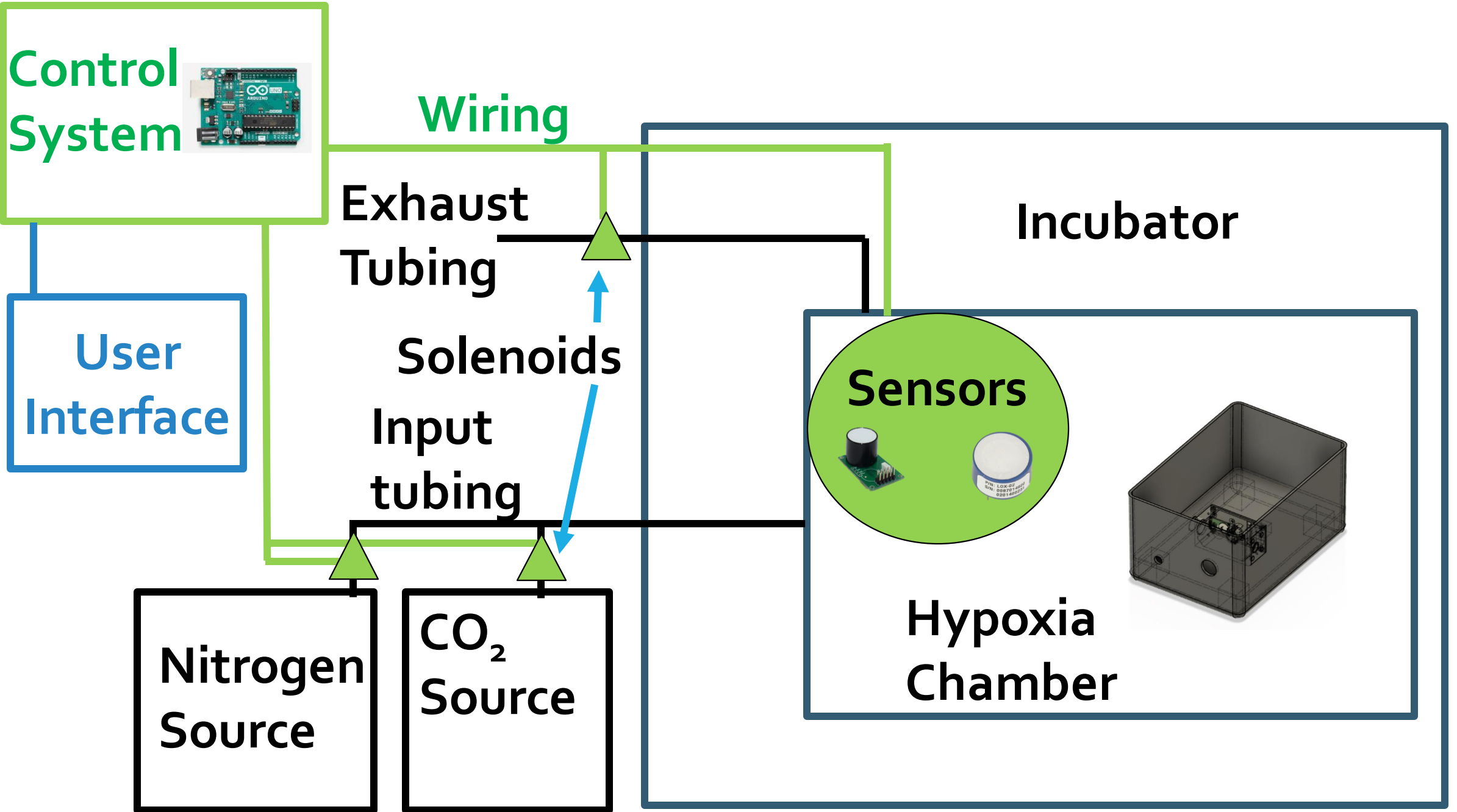
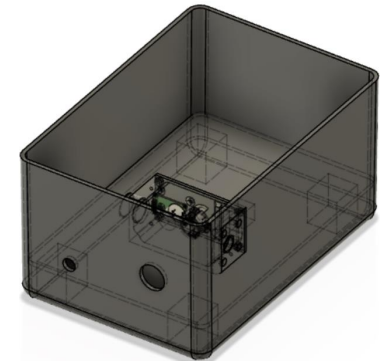
Sensors



Nitrogen Source

CO₂ Source

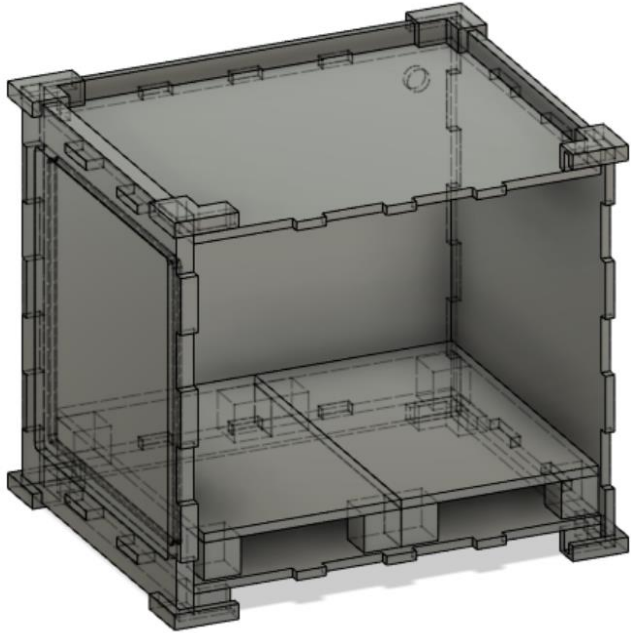
Hypoxia Chamber





Chamber Design Solutions

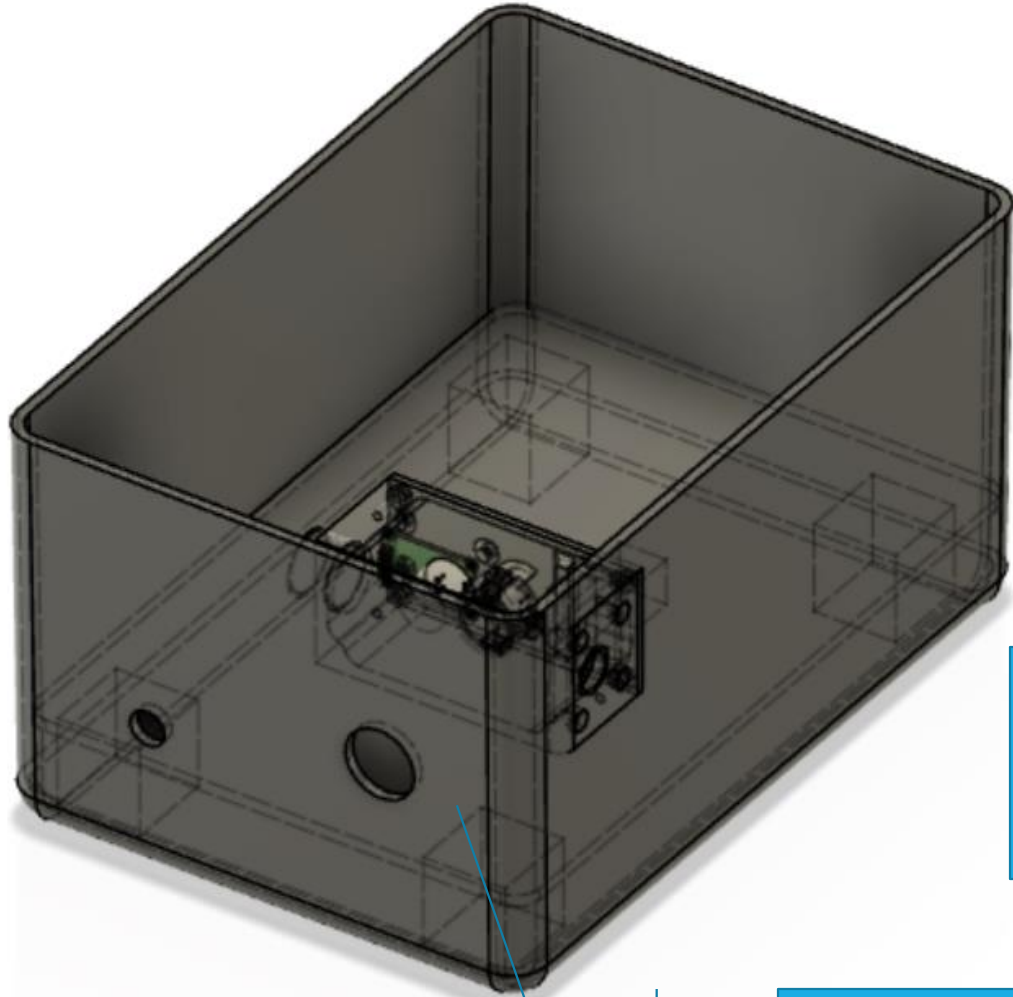
Custom Chamber Prototype 1



- Acrylic piece was laser cut
- Ethanol, the solvent to be used for sterilization, was used to clean the piece post-cutting
- We discovered that ethanol causes crazing within the acrylic, which affects the structural integrity



Final Chamber Design

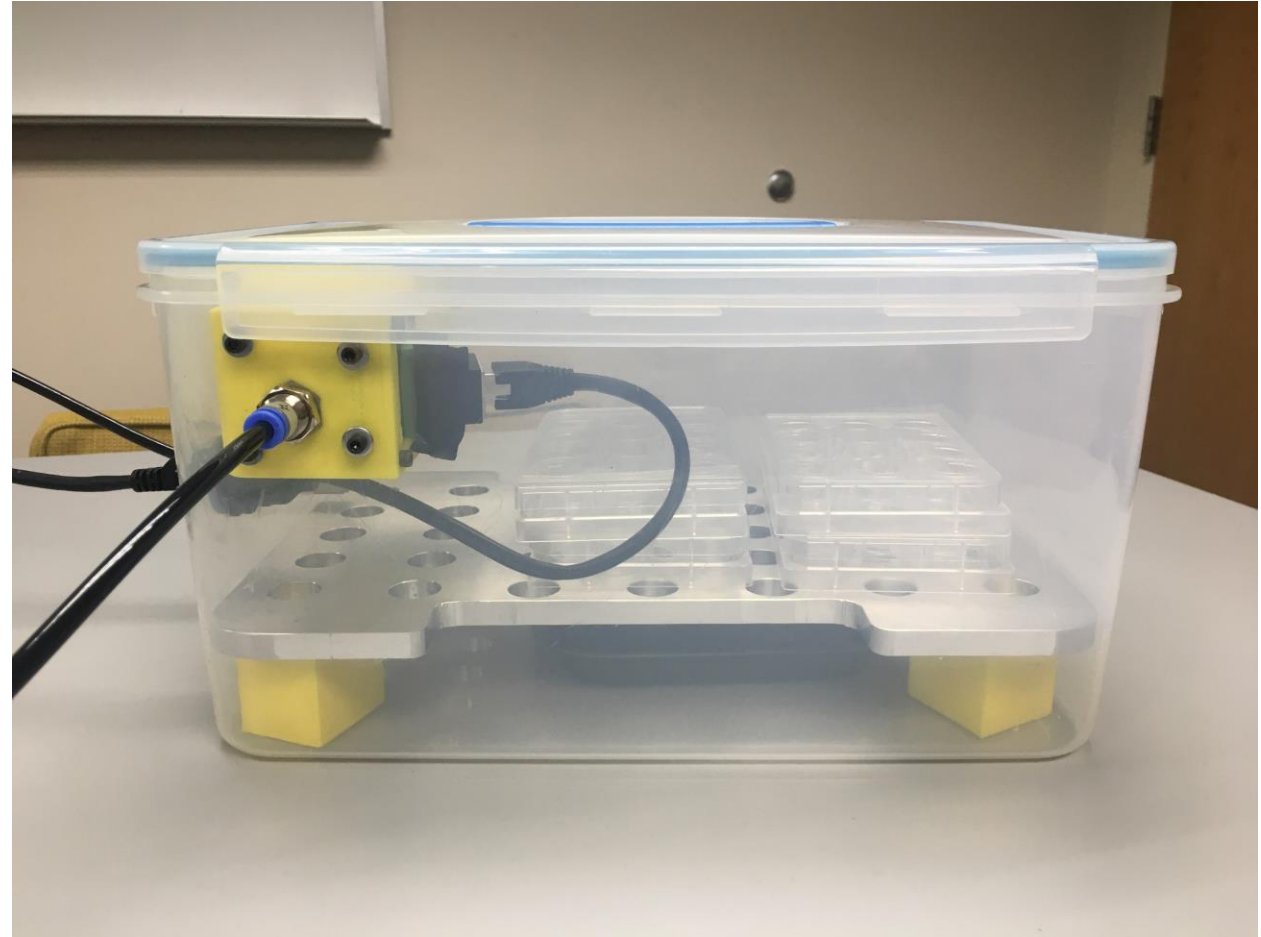


Handle and
door seal



Guaranteed
airtight

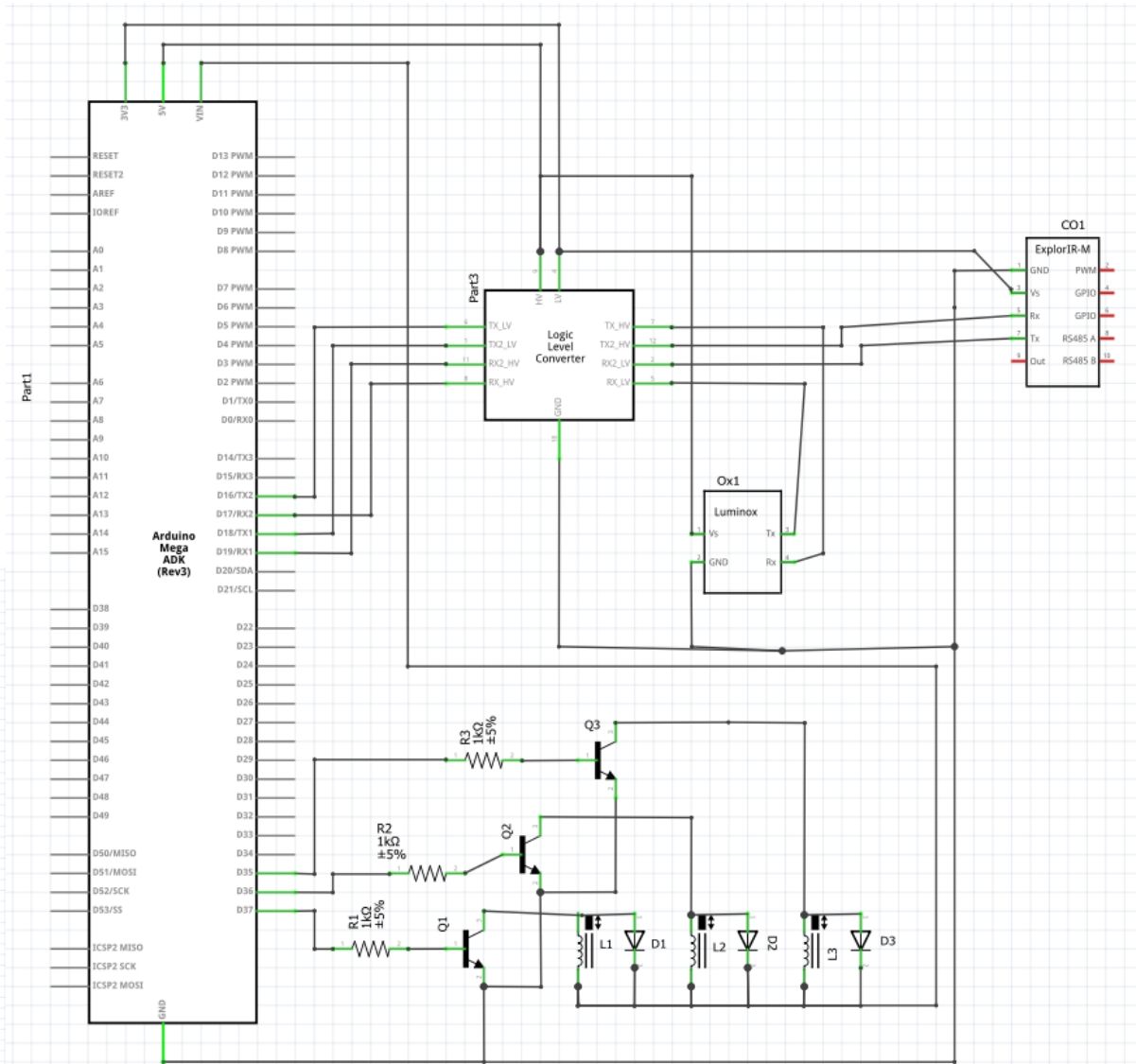
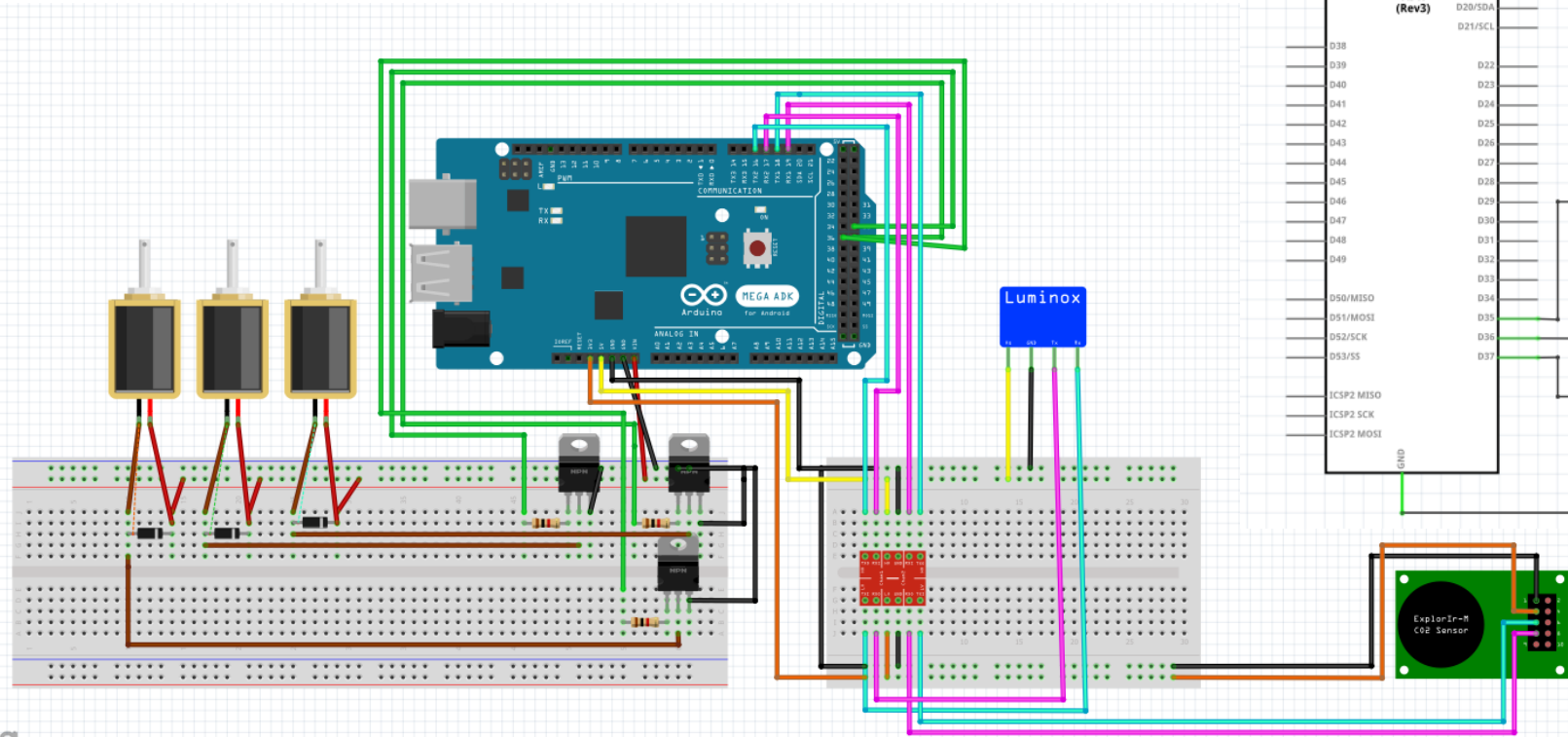
Ample space for several well plates,
humidity control system, and sensors





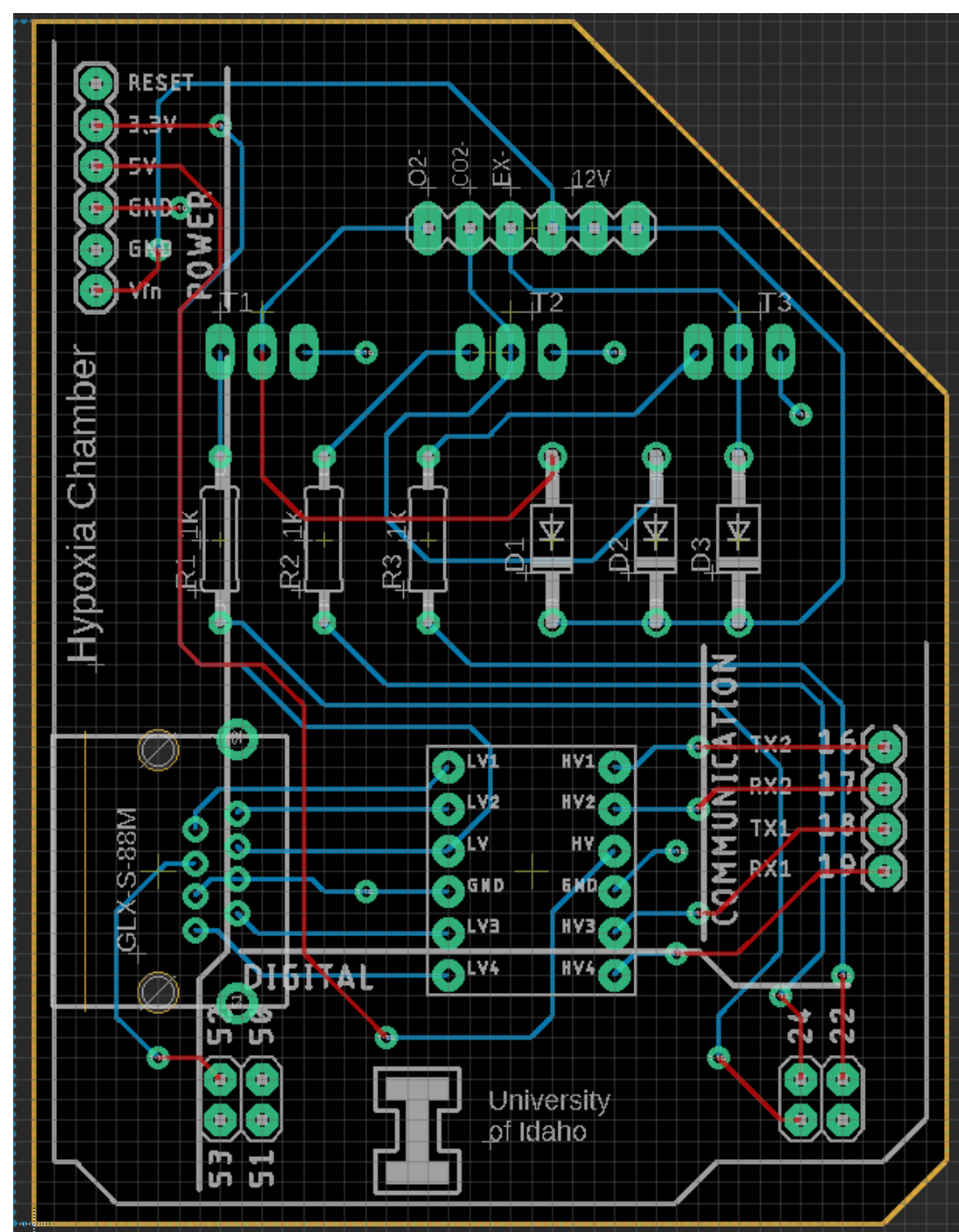
Control System

- Arduino Mega with multiple serial ports
- 3 Solenoids to control airflow, with diodes, resistors, and BJTs
- O₂ and CO₂ sensors connected through level converter



PCB

- Pin headers for solenoid connections
- Ethernet connector for sensors
- Adapter board for sensor UART communication
- Resistors, diodes, and transistors for solenoid circuitry
- Pin headers on underside allow PCB to snap on top of Arduino

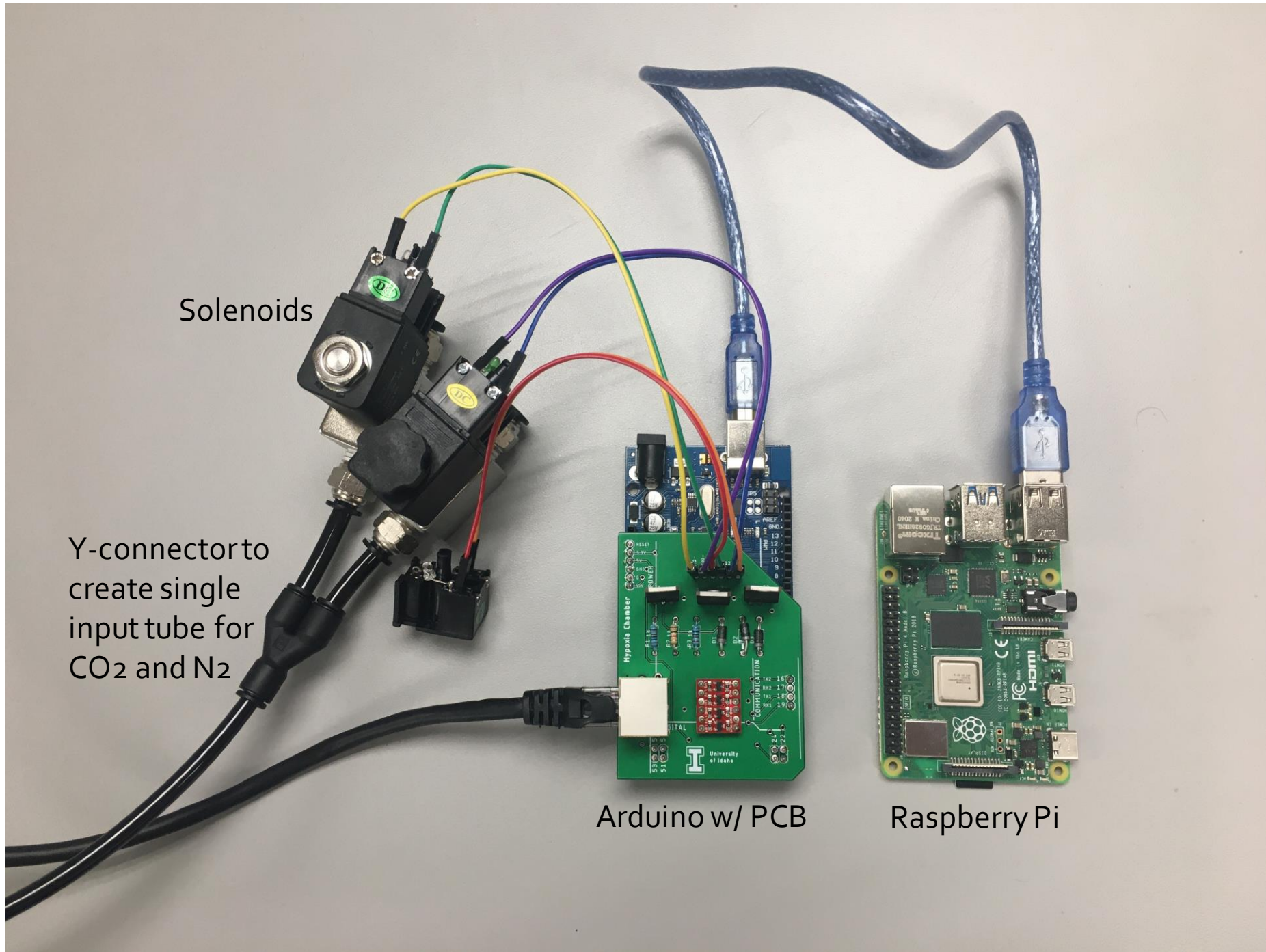


Solenoids

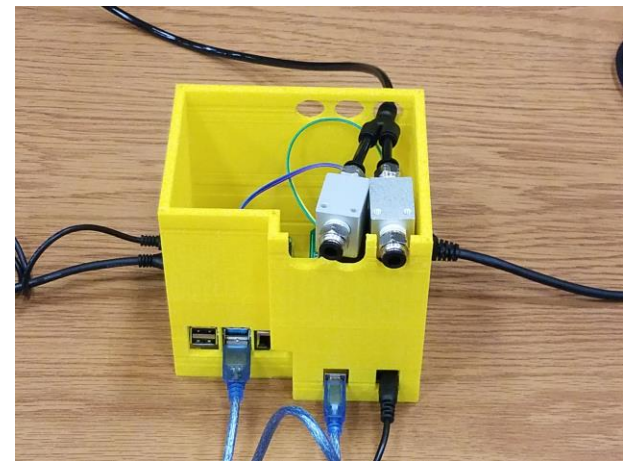
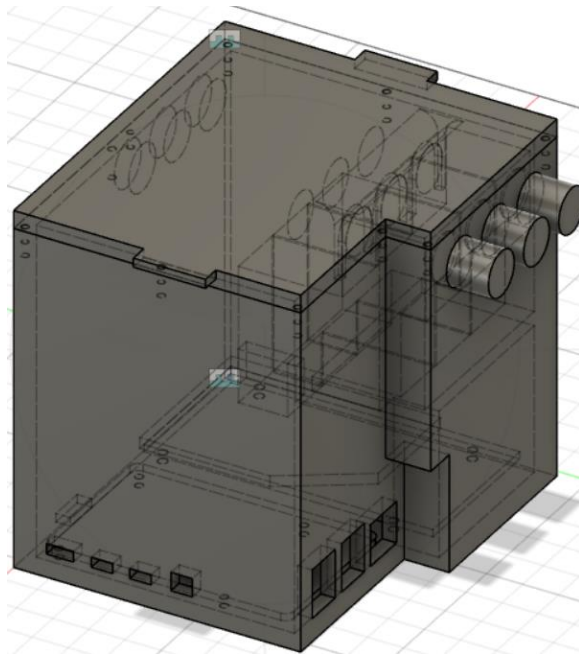
Y-connector to
create single
input tube for
CO₂ and N₂

Arduino w/ PCB

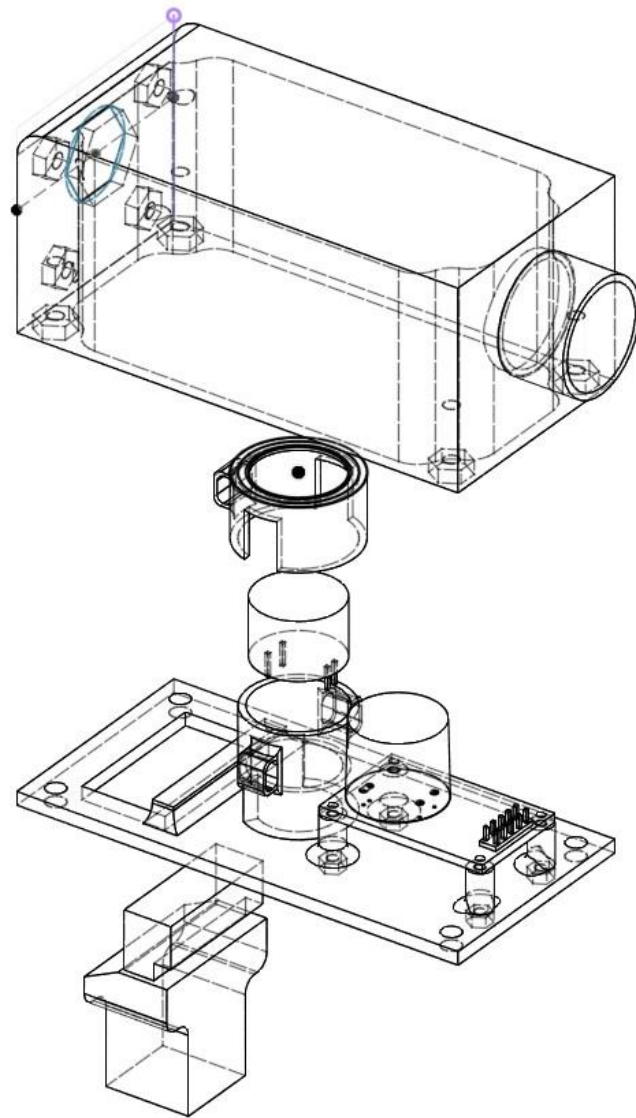
Raspberry Pi



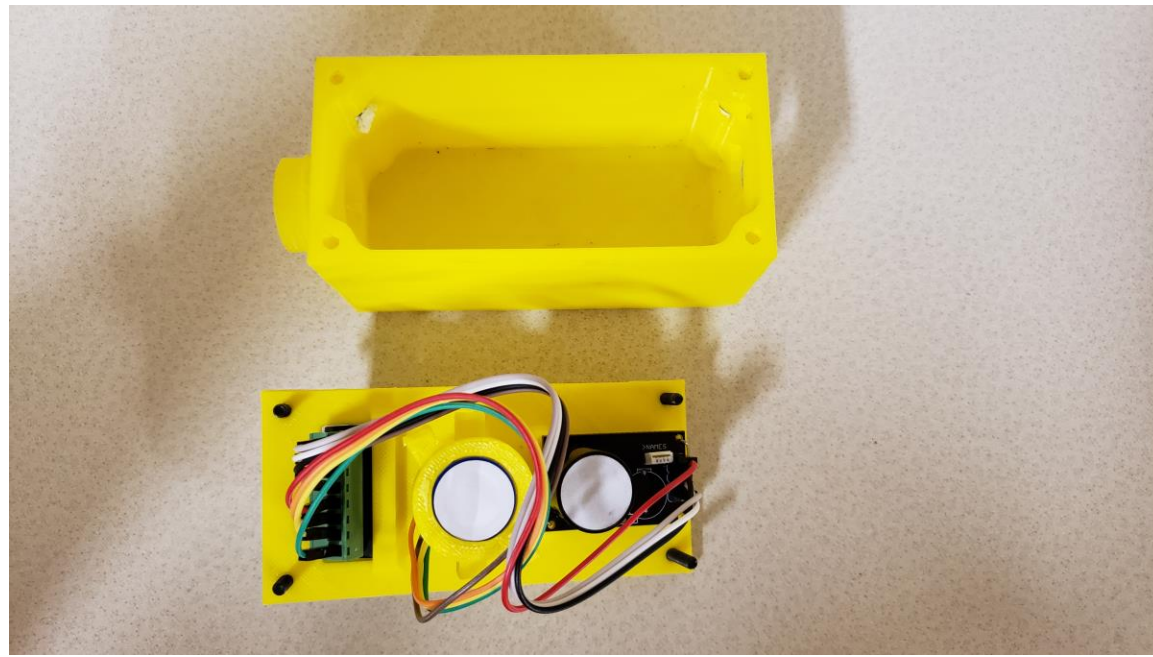
Electronics Housing



Sensor Housing



Printed Sensor Housing



GUI

Low-Cost Controllable Hypoxia Chamber
HYPEngineers
University of Idaho

Input Target Values

Percent Oxygen
5
Current Target Value: -%

Percent Carbon Dioxide
5
Current Target Value: -%

Pressure Calibration
940
Current Target Value: -mBar

Set values

Folder path to save data to:
Insert file name here: Filename Suffix
Browse D:/.../MMDDYY_HHMM_FilenameSuffix.csv
Submit file path Export file

Current Conditions

Current percent oxygen
-

Current percent carbon dioxide
-

Current temperature in Celsius
-

Current percent relative humidity
-

Current pressure in mBar
0

Begin Experiment

Pause Experiment

Any notifications will appear here.

PID Settings Save Settings To File

Connect Arduino Load Settings From File

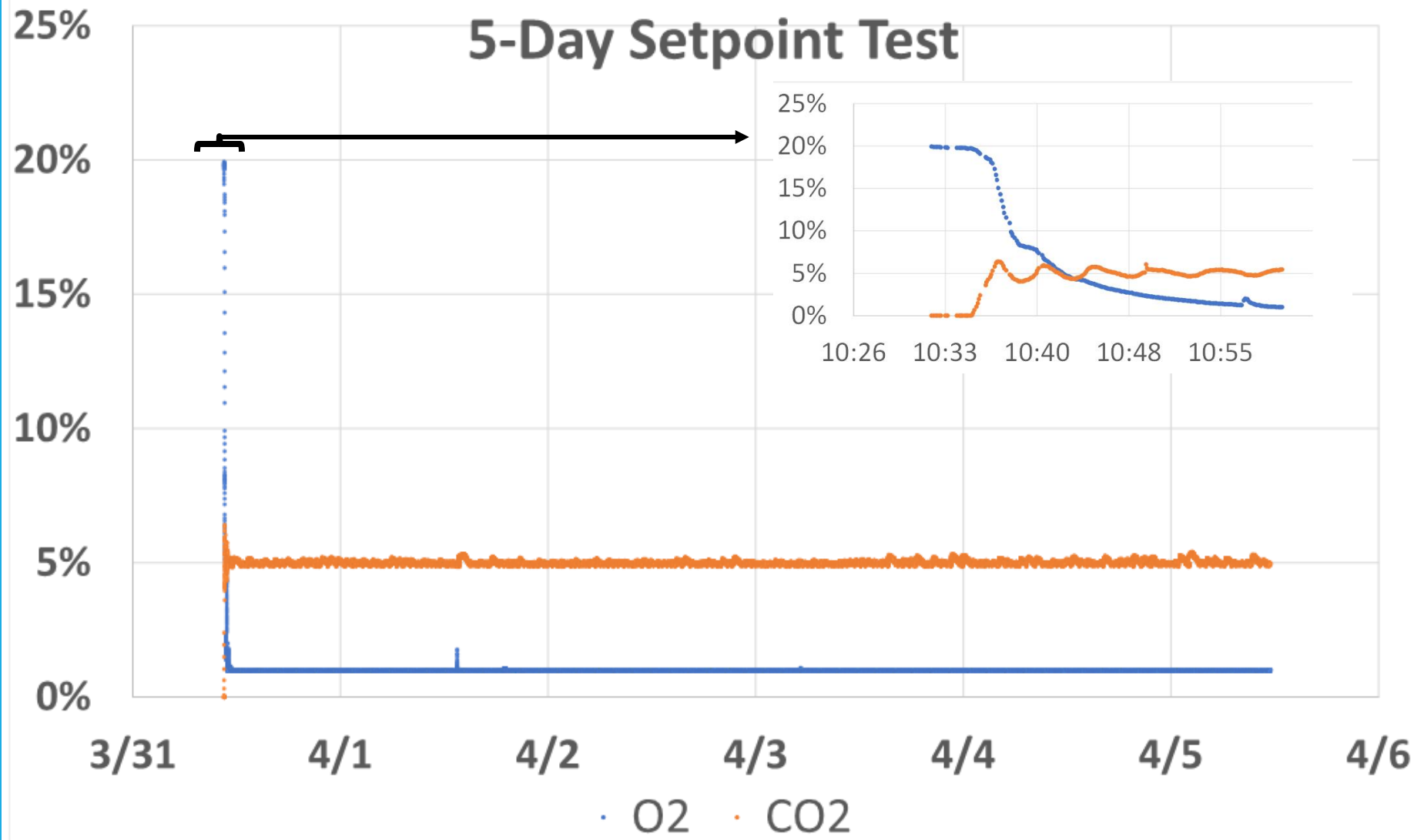


Design Validation and Testing

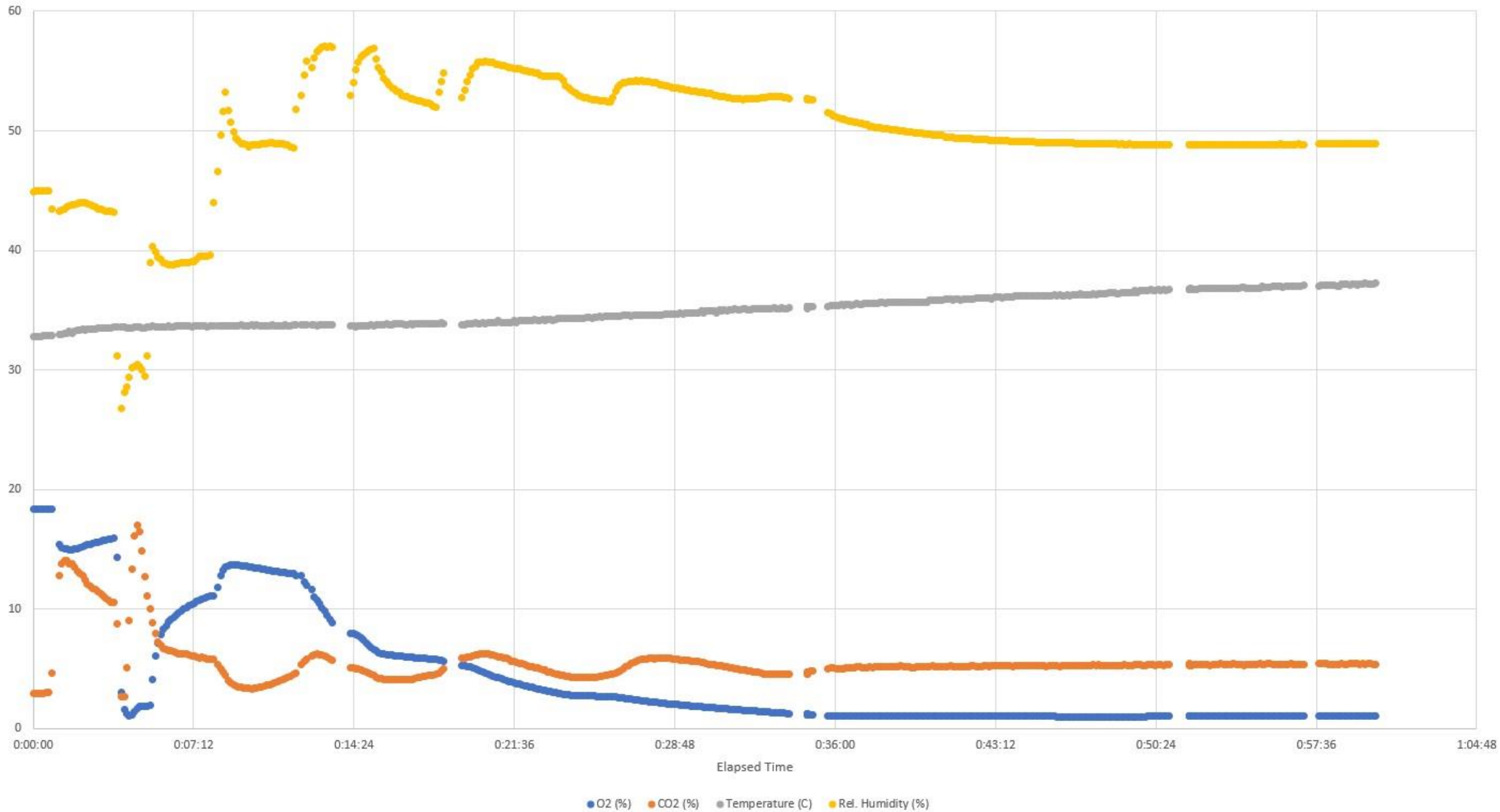
Design Validation

Requirement	Testing
Maintain a hypoxic environment (1% O₂ and 5% CO₂) for at least 21 days	<ul style="list-style-type: none">• Run control system to pump the correct % of gas in to create hypoxic environment• Use sensors for daily measurements for 5 days
Airtight/Pressure Test	<ul style="list-style-type: none">• Slightly pressurize chamber and use soapy water to check for bubbles on all edges
Reach hypoxic conditions within 30 minutes	<ul style="list-style-type: none">• Create a setpoint on the GUI and check if it reaches that level within 30 minutes.
Product must be durable to sterilization procedures	<ul style="list-style-type: none">• Review the properties of the components used
Sensors read accurate data to the Arduino	<ul style="list-style-type: none">• Connect the O₂ and CO₂ sensors to the Arduino and try and get sensors values
Disable functionality when the lid is opened	<ul style="list-style-type: none">• Create a switch on the GUI to alert when the lid is open and disable input of gas
Achieve 95% humidity within the chamber	<ul style="list-style-type: none">• Place a well of water or saturated sponge in the chamber and measure humidity over a day period

5-Day Test



Incubator Test



Paper

Results of our project will be published in HardwareX

HardwareX is an open access journal for free and open source scientific hardware

This paper will detail the motivation, design, construction and function of our chamber

Hardware 

Open access journal
dedicated to open source
scientific hardware



www.journals.elsevier.com/hardwareX

Looking Forward/ Future Improvements

Chamber Design

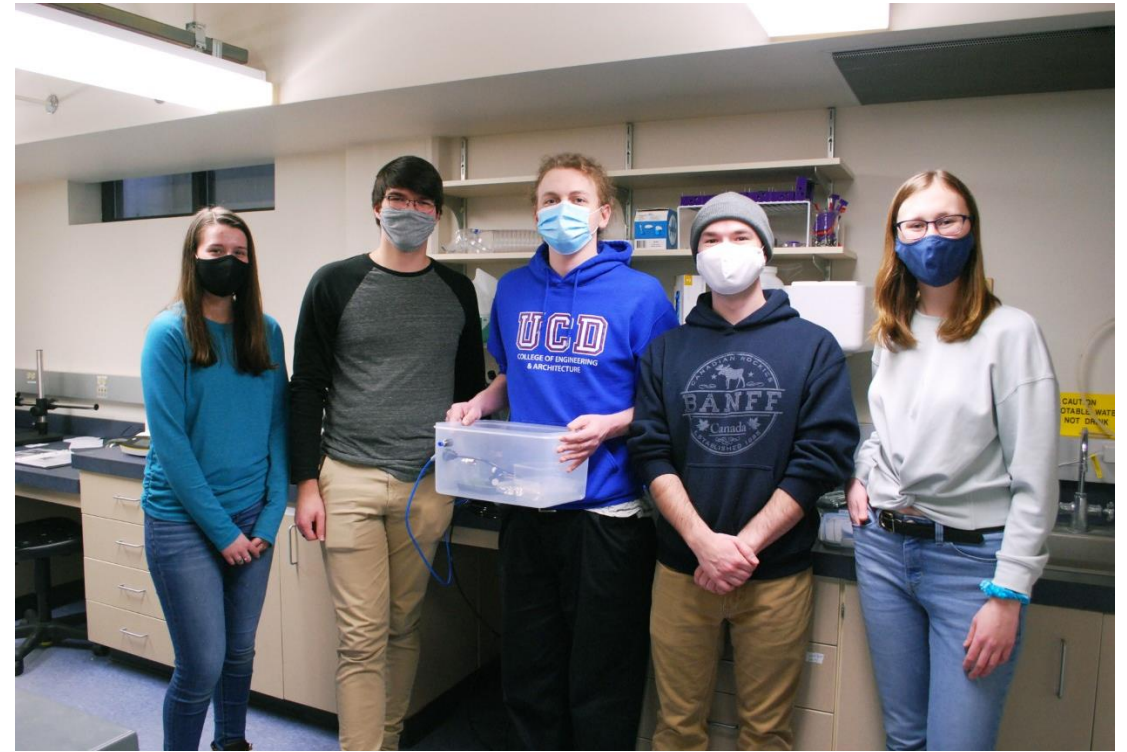
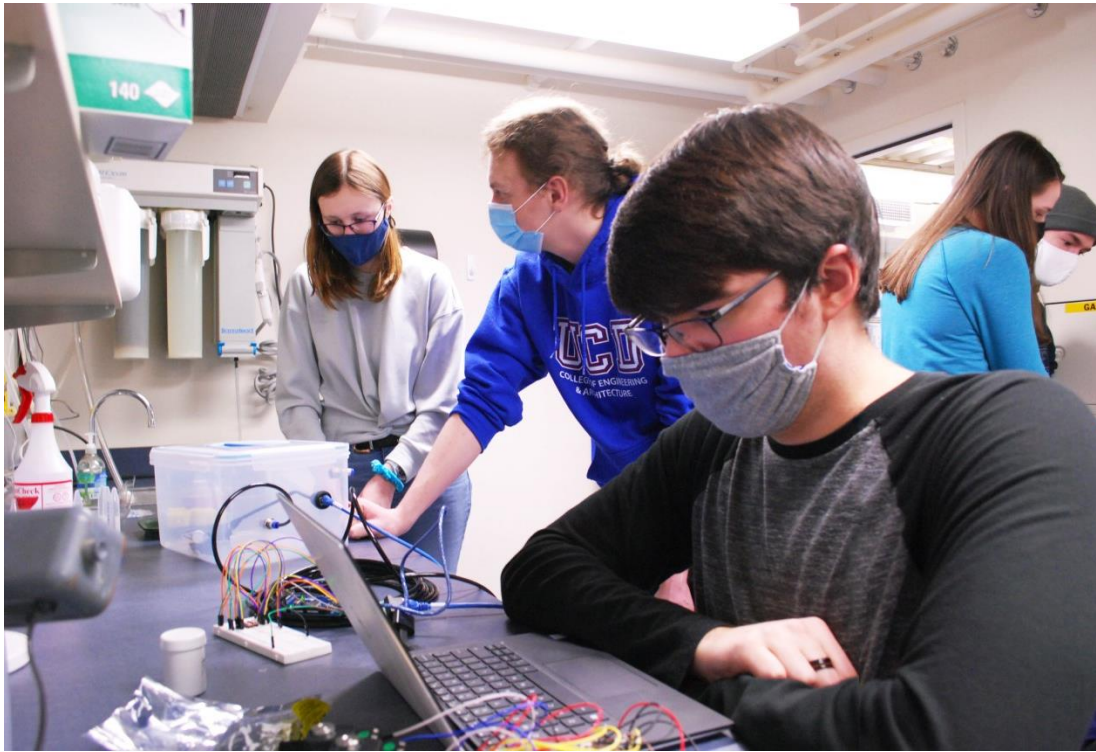
- Finish developing the custom chamber design

GUI

- Addition of real time graphs of gas concentrations
- Remote connectivity

PCB inside sensor

- Create 2nd PCB for inside sensor housing
- Direct connection for O₂ and CO₂ sensors



Thank you. Any questions?