

Establishing a Cyber-Physical Network of Microcontrollers and Thermodynamic Sensors for Real-Time Environmental Monitoring



Madison Howard

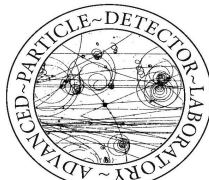
Advanced Particle Detector Laboratory

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Motivation

- Advanced Particle Detector Laboratory
 - CERN, CMS
- Monitor Conditions
 - Dashboard
 - Alerts

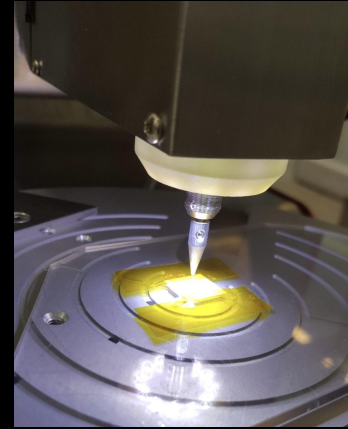


Fig 1. Royce 610
Pull Tester

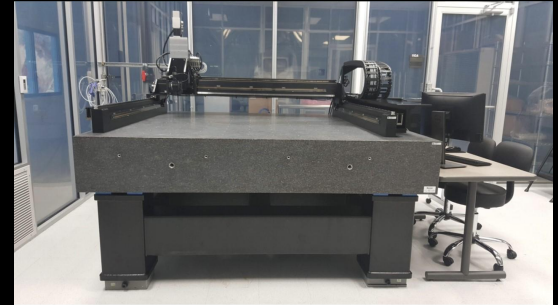
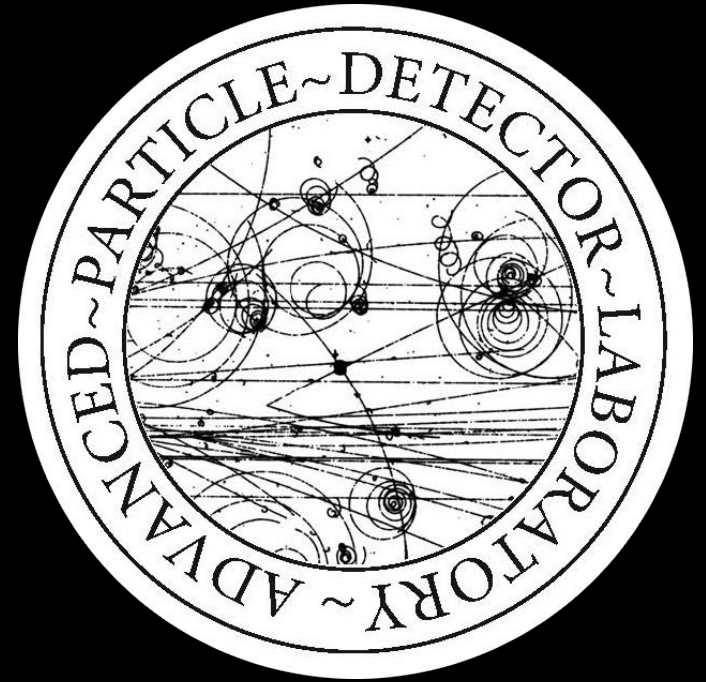


Fig 2. Clean Room

Overview

- Hardware
 - Raspberry Pi
 - BME280 Sensor
 - Cases
- Software
- Looking Forward



Hardware: Raspberry Pi

- What is a Raspberry Pi?
- What are they used for?
- Why am I using them?

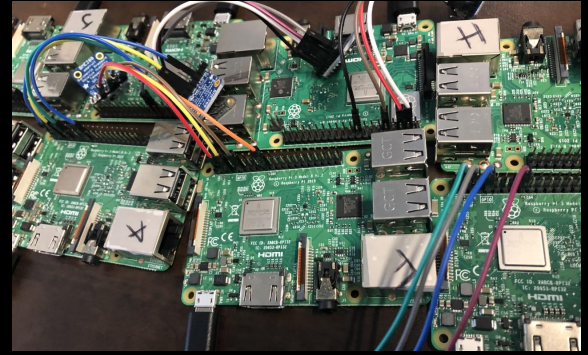


Fig 1. Raspberry Pis

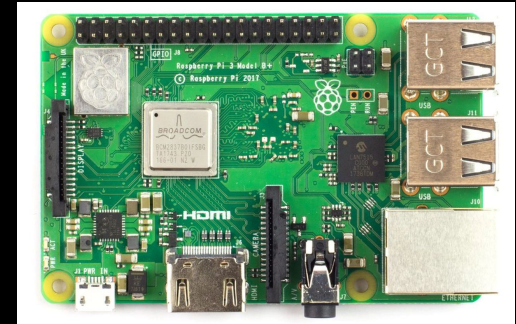


Fig 2. Raspberry Pi B+

Hardware: BME280

- What is a BME280?
- Establishing connection
 - Soldering and Wiring

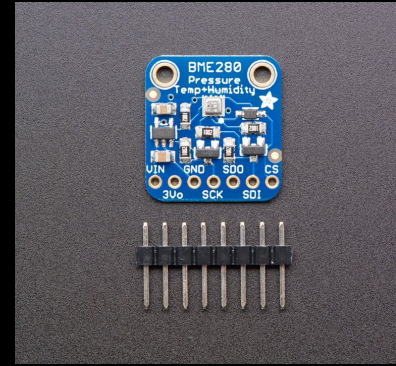


Fig 1. Unsoldered BME280 Sensor

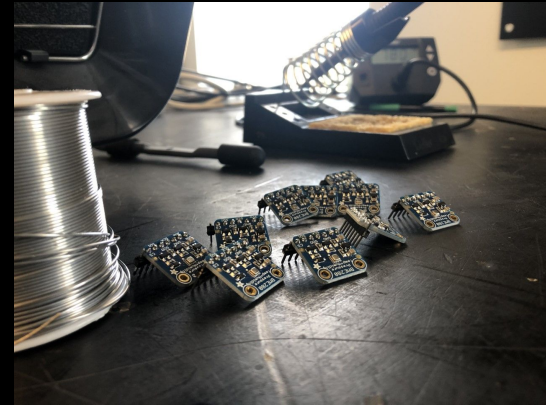


Fig 2. Soldering the BME280's

Hardware: Cases

- Raise3D
- Issues Without a Case



Fig 1. Raspberry Pi Without a Case

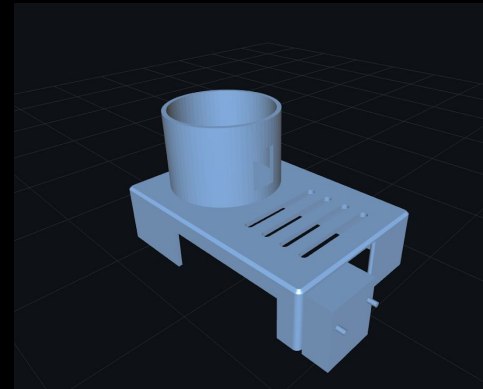
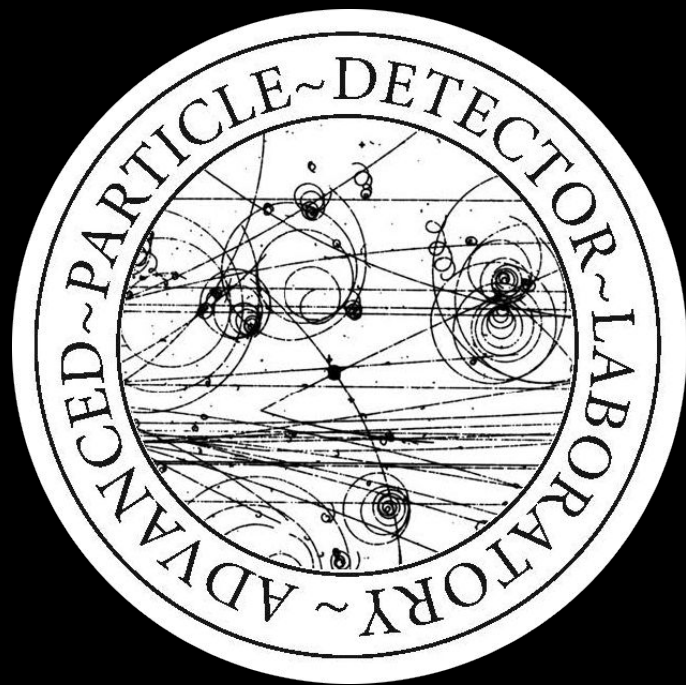


Fig 2. STL Rendering of
the Raspberry Pi Case

Overview

- Hardware
- Software
 - Data Acquisition
 - MQTT
 - Database
 - Alarm System
 - Data Visualization
 - Dashboard
- Looking Forward



Data Acquisition: MQTT

- MQTT
 - Flowchart
- Sensor Out Code
 - Adafruit library
 - I/O Relations and Storage

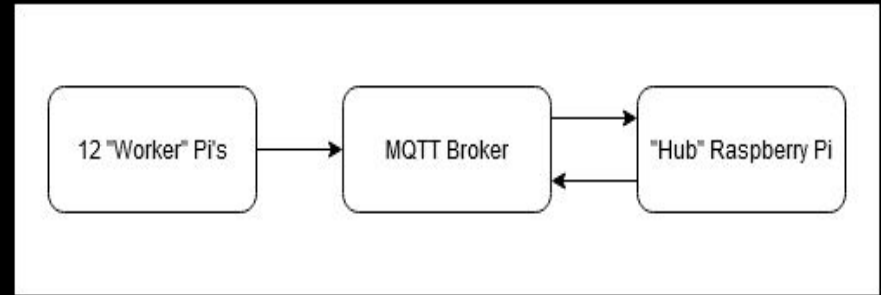


Fig 1. MQTT Client Broker Flowchart

Data Acquisition: Database

- MySQL
- Database Schema

E	2021-03-07 15:53:49	73.35	22.39	90.63
D	2021-03-07 15:54:55	74.46	22.77	90.65
C	2021-03-07 16:00:52	73.84	22.98	90.59
A	2021-03-07 16:00:52	74.15	21.83	90.61
G	2021-03-07 16:00:52	74.15	21.98	90.61
B	2021-03-07 16:00:54	75.5	21.18	90.6
F	2021-03-07 16:00:54	73.26	23.27	90.58
I	2021-03-07 16:00:57	75.18	20.92	90.59
E	2021-03-07 16:08:50	73.56	22.29	90.63
D	2021-03-07 16:09:55	74.68	22.65	90.64

Fig 1. Data in MySQL Database

Field	Type	Null	Key	Default	Extra
Pi_ID	varchar(50)	YES		NULL	
Date	datetime	YES		NULL	
Temp	float	YES		NULL	
Humidity	float	YES		NULL	
Pressure	float	YES		NULL	

5 rows in set (0.00 sec)

Fig 2. Database Schema

Software: Data Visualization

- Time Series Plots

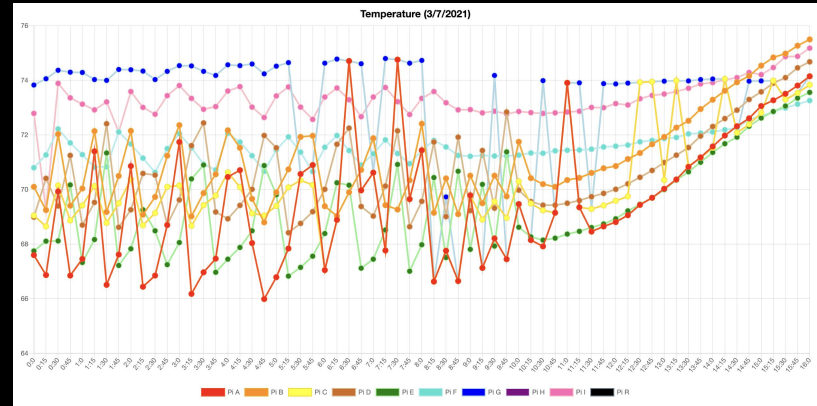


Fig 1. Temperature Versus Time Graph

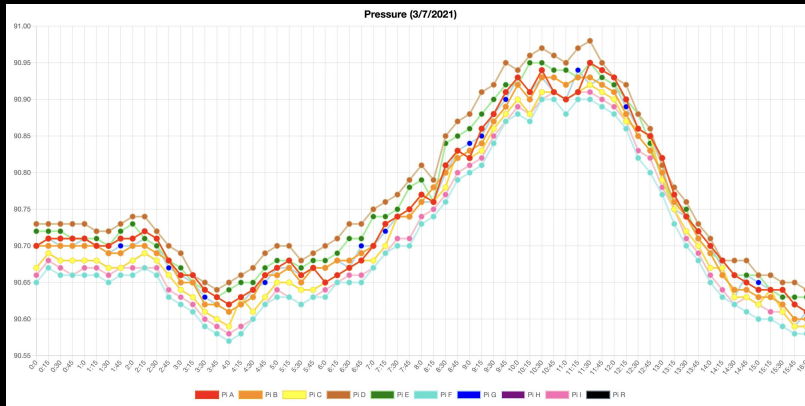


Fig 2. Pressure Versus Time Graph

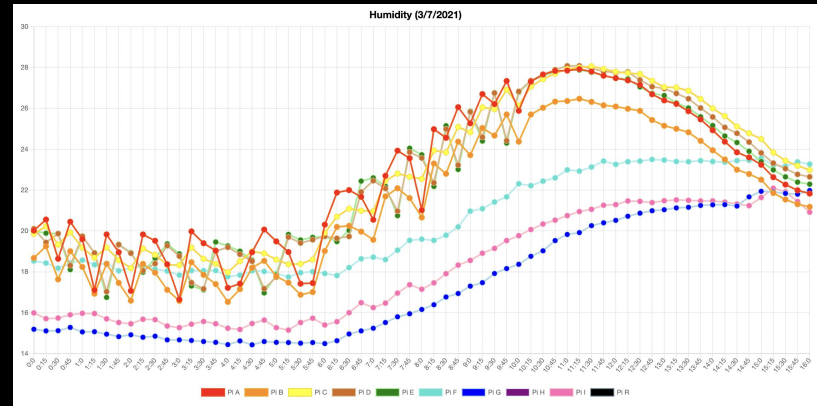


Fig 3. Humidity Versus Time Graph

Software: Alarm System

- SMTP
 - Emailing
 - Texting
- Debouncing

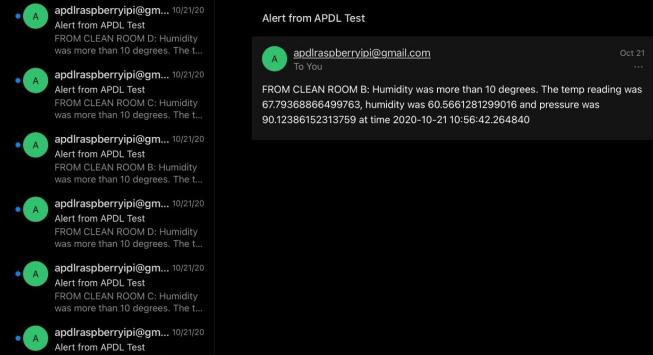


Fig 1. Raspberry Pi Emails

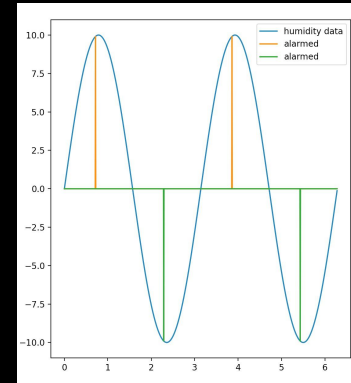


Fig 2. Debouncing Simulation Graph

Software: Dashboard

- [Live Demo](#)

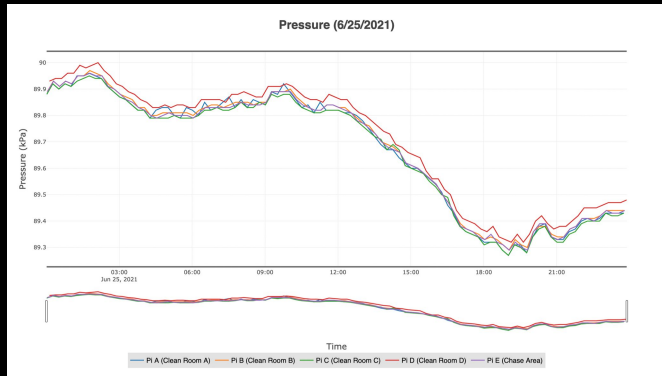
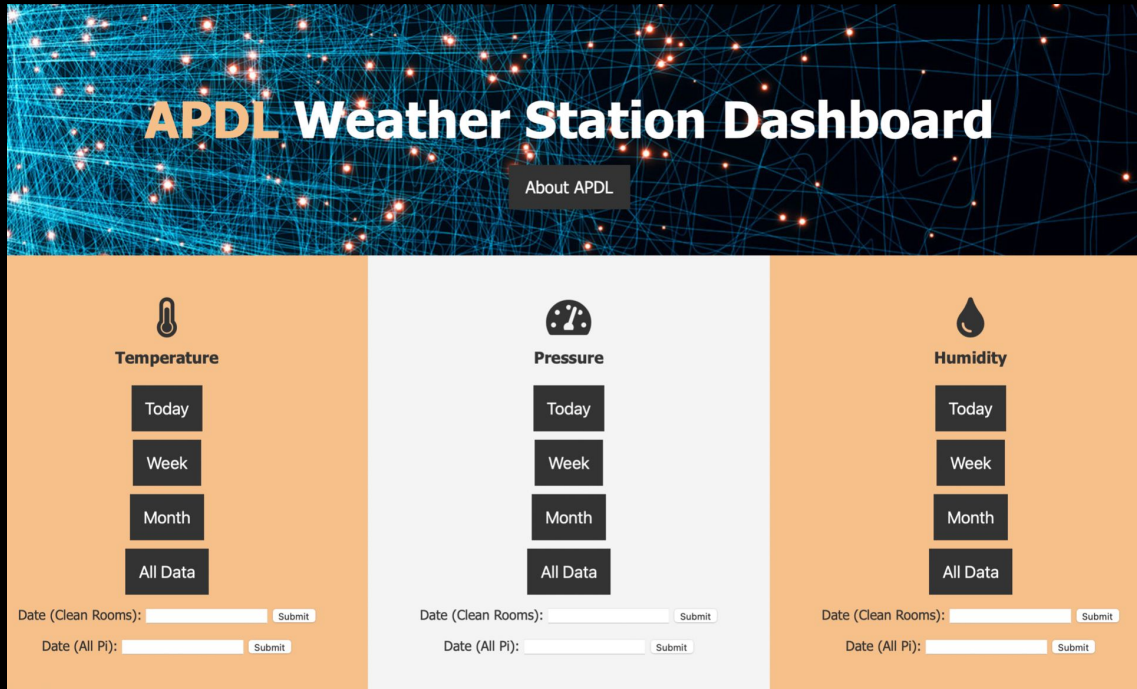


Fig 2. Dashboard Plot

Fig 1. APDL WS Home Page

Looking Forward

- Particle Counter Data
- HVAC Incorporation
- WIFI Network
- Machine Learning
 - Weather Patterns
- Commercialization Potential

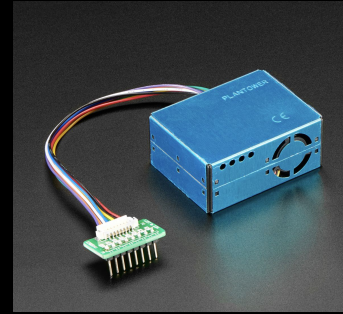


Fig 1. Particle Counter



Fig 1. HVAC Company Logo



Fig 3. Weather



Fig 4. WIFI