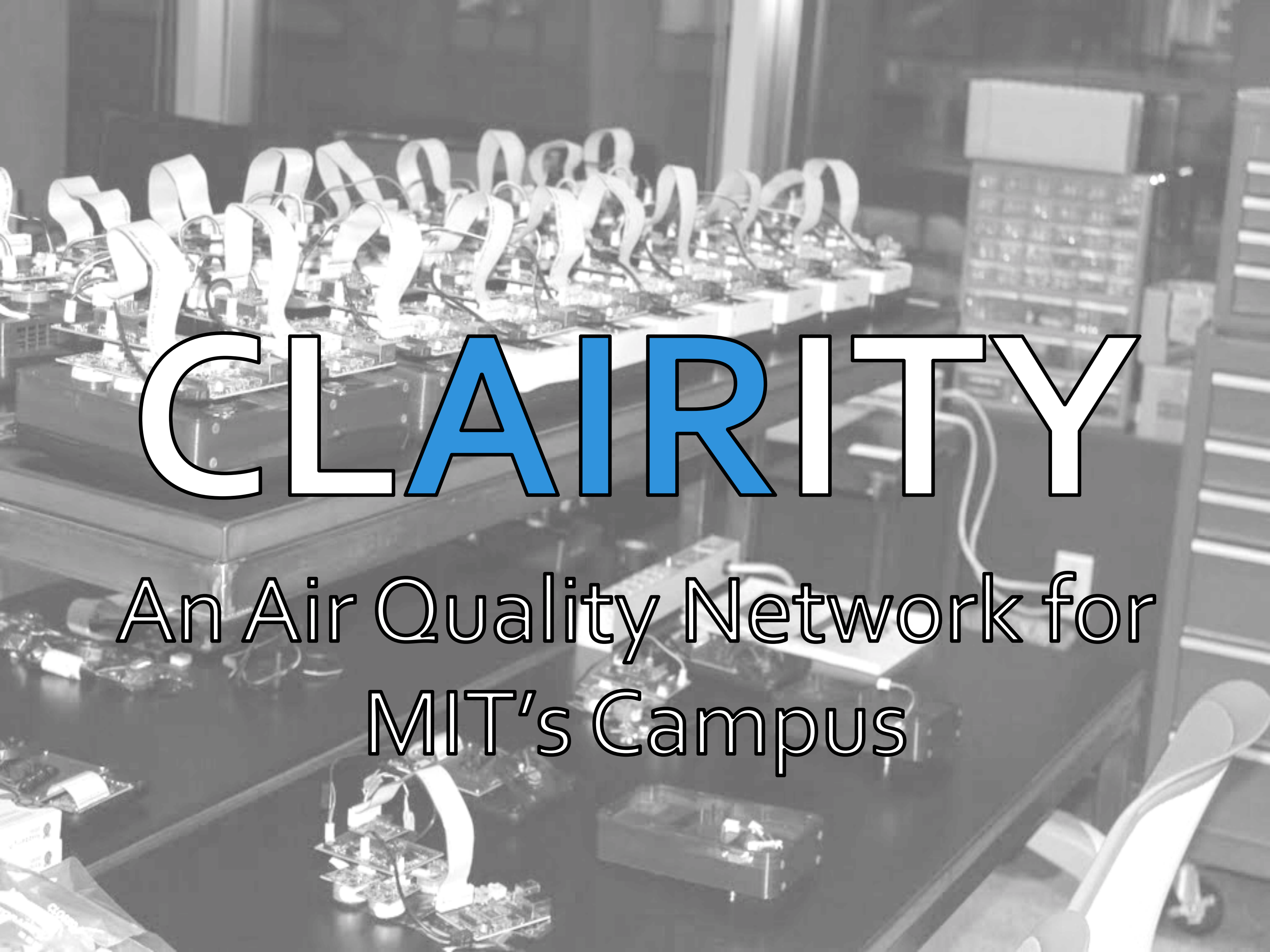


# CLAIRITY

## An Air Quality Network for MIT's Campus

08/21/2013 | Source: Alex Hofford/EPA/Landov



# Real-time
# High resolution

CLAIRITY.MIT.EDU

# CLAIRITY Locations

**Food Service Areas**

Parking Areas

Major Intersections

Roofs

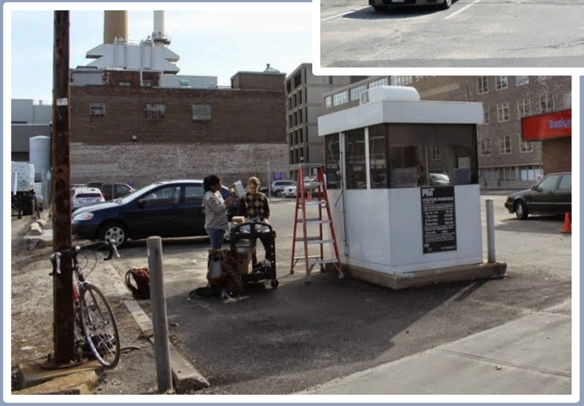
Community Cross Section

- Next Dining
- Student Center
- Burton Connor Suite Kitchen
- Café 4


# CLAIRITY Locations

Food Service Areas
Parking Areas
Major Intersections
Roofs
Community Cross Section

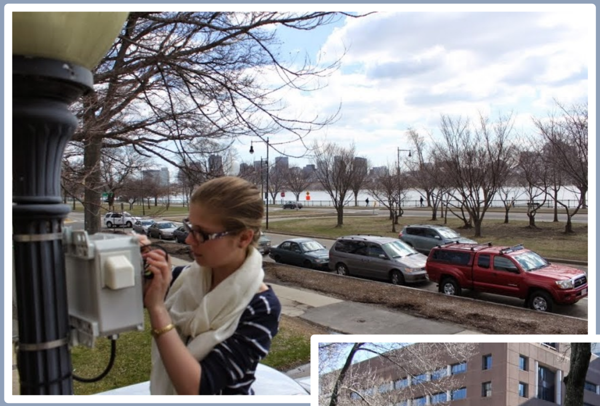
- Kresge Parking
- West Parking Garage
- Mass. Ave. & Vassar St. Parking
- Stata Loading Dock
- MIT Medical Parking

# CLAIRITY Locations

Food Service Areas
Parking Areas
Major Intersections
Roofs
Community Cross Section

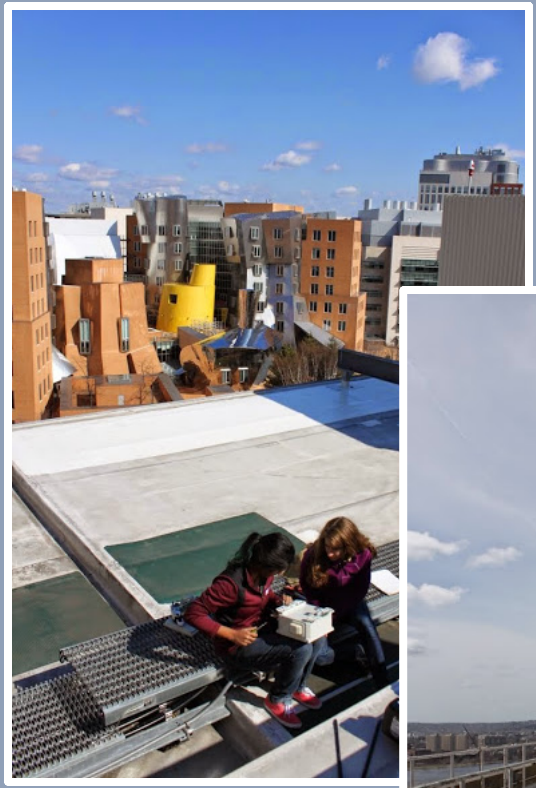
- Ames St. and Amherst Alley
- Main St. and Vassar St.
- Mass. Ave. & Memorial Dr.
- Memorial Dr. (Walker Memorial)

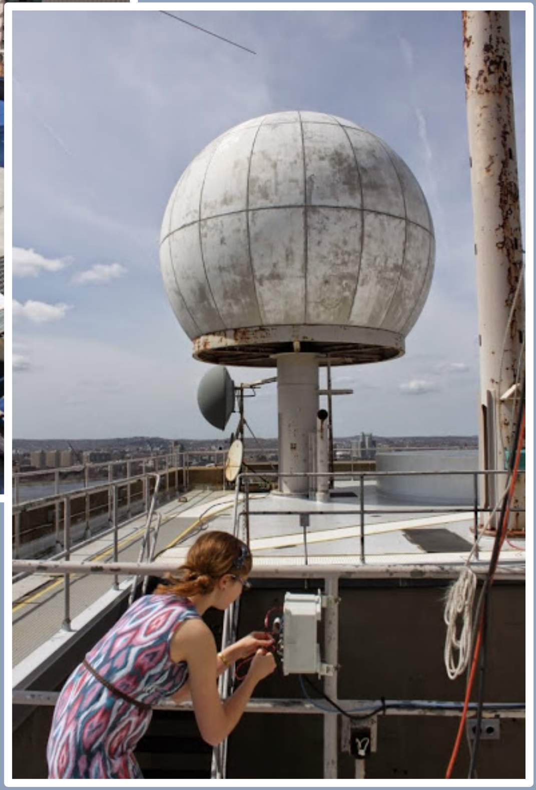


# CLAIRITY Locations

Food Service Areas
Parking Areas
Major Intersections
Roofs
Community Cross Section

- Green Building Roof
- Building 16 Roof

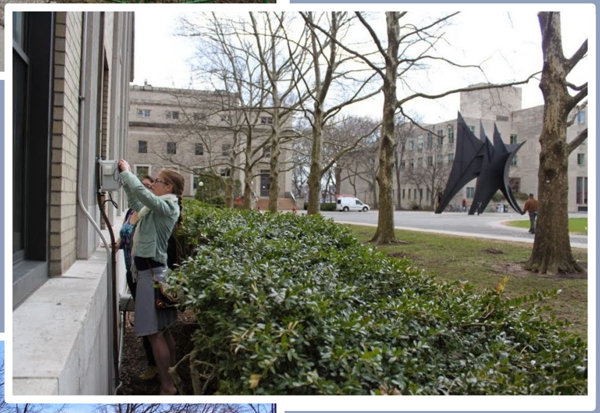




# CLAIRITY Locations

Food Service Areas
Parking Areas
Major Intersections
Roofs
Community Cross Section

- MIT Museum
- Cogeneration Power Plant
- Briggs Field
- Next House Courtyard
- MIT Facilities Vehicle
- Killian Court
- Green Building
- Sloan School
- Tech Shuttle




STOP
STOP
BEWARE OF
PEDESTRIANS

# Project Timeline

Fall 2013

- Chose which pollutants to measure
- Chose sensors to use
- 1st iteration of node design

Spring 2014

- Built & calibrated 25 nodes
- Installed throughout MIT
- Developed software
- Created the CLAIRITY website

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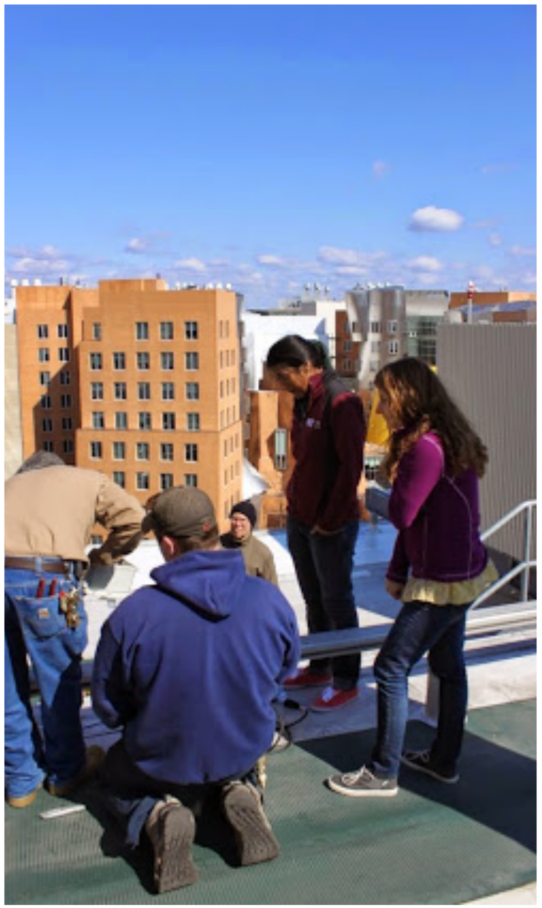
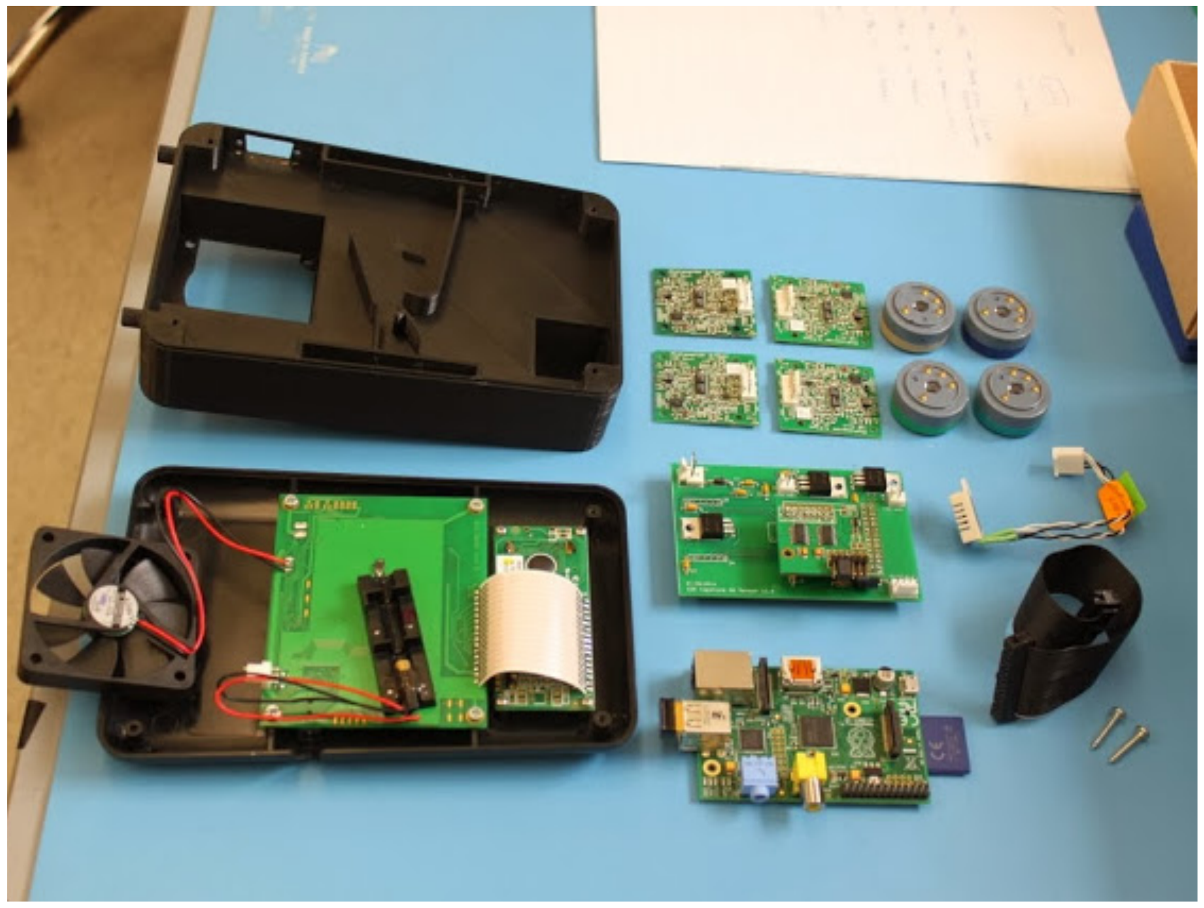


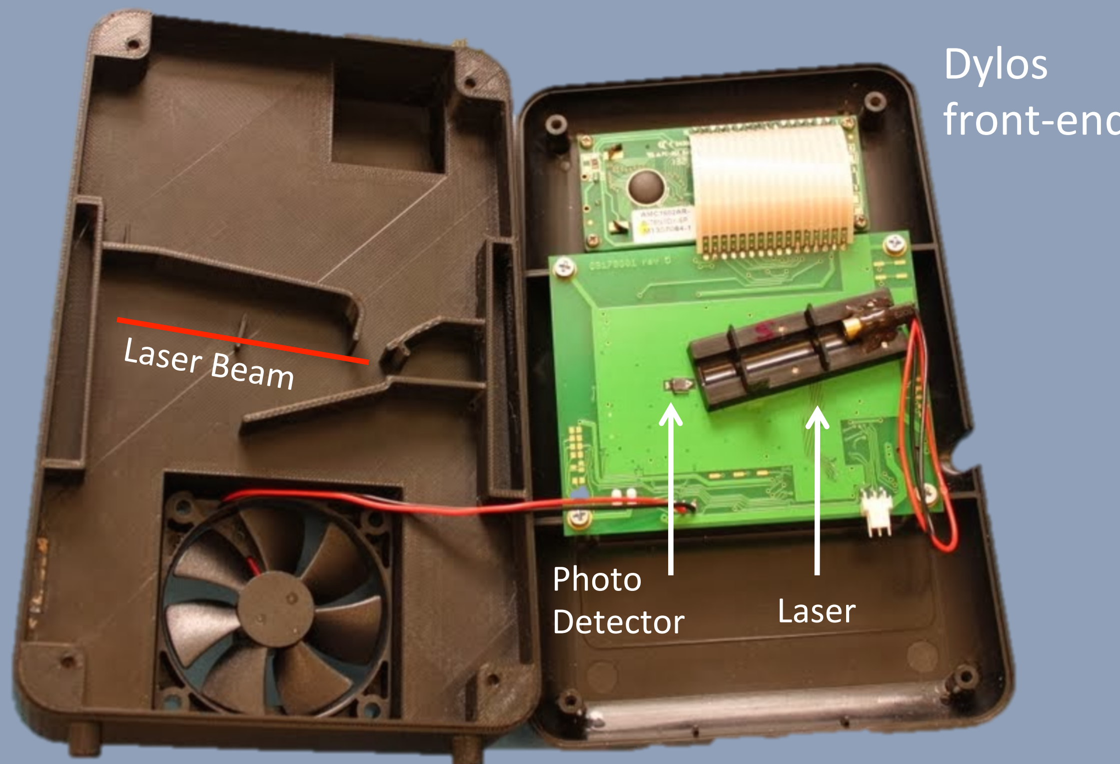
# Node Hardware

- Dylos Particle Counter
- 4 Electrochemical Gaseous Pollutant Sensors
- Raspberry Pi processor



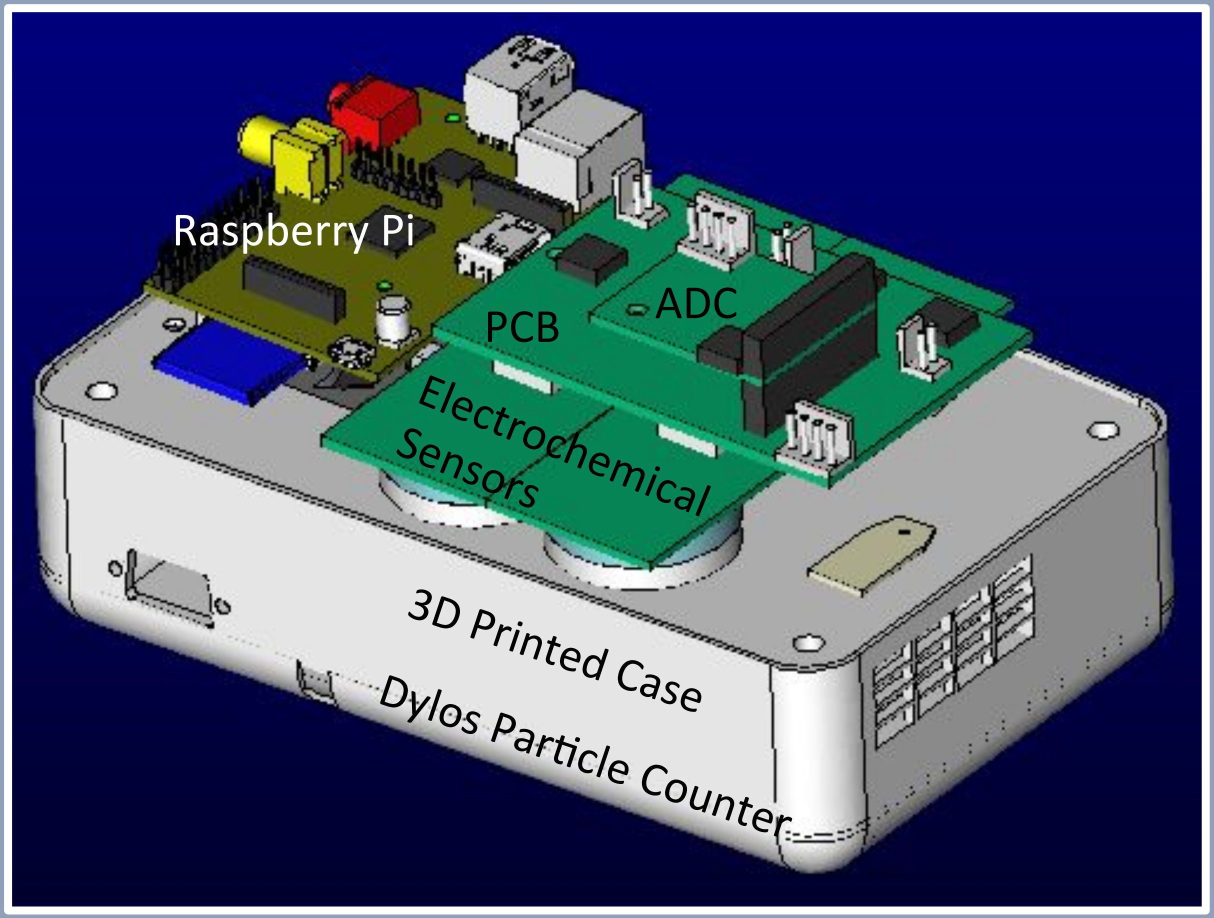
# Node Hardware

Front of 3D Printed Case




Back of 3D Printed Case

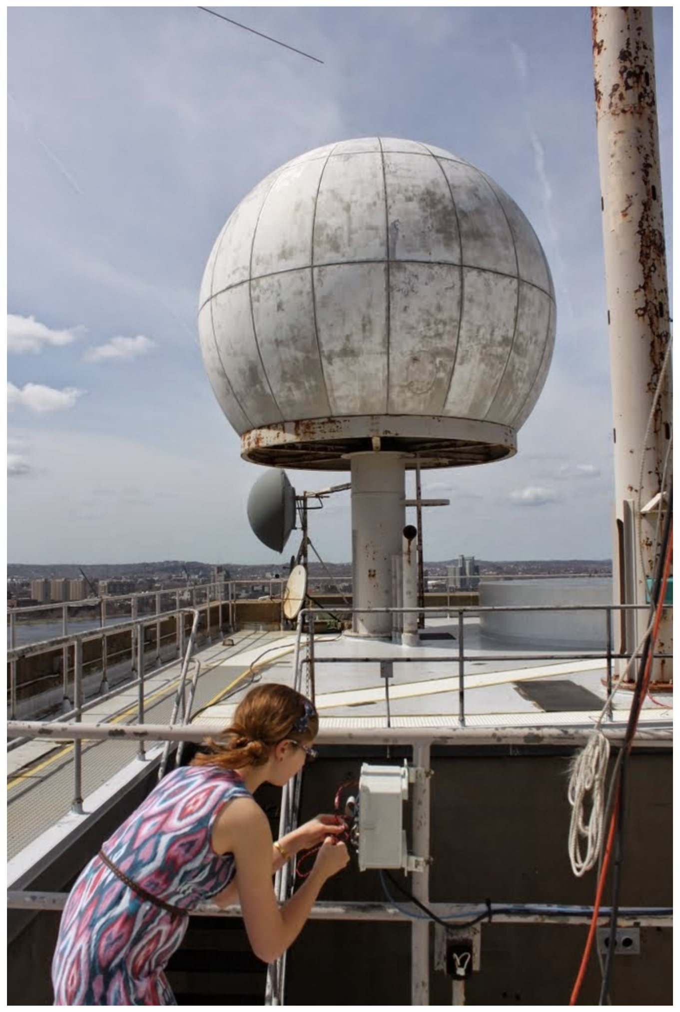
# Node Hardware



# Data Progression

Raw Voltage from Node → Raw Voltage Sent to Database → Voltage converted in Database

# Data Transmission and Reliability



## Transmission

- Compatibility with ethernet
- Multiple email updates

## Reliability

- Security
- Averaging function

# Challenges and Result

## Primary Challenge

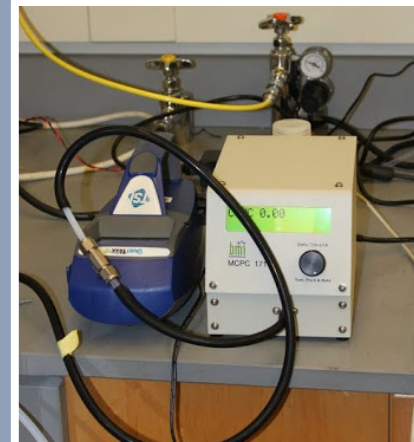
- Code iterations

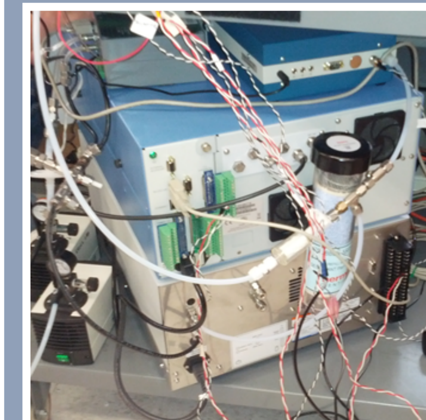
## Result

- Integrated system
- Organized data storage

# Calibration Process

CO | NO | $NO_2$ | $O_3$ | PM 2.5 | PM 10



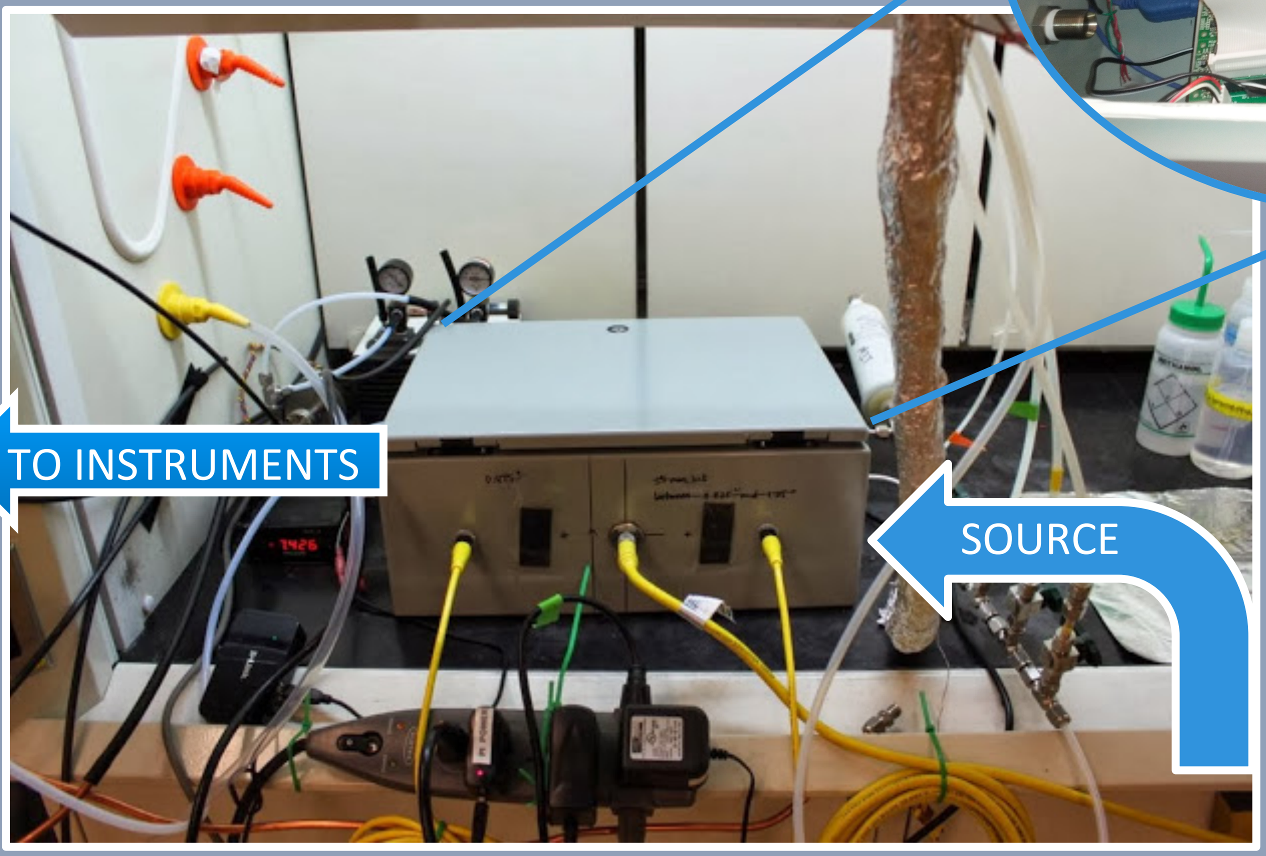



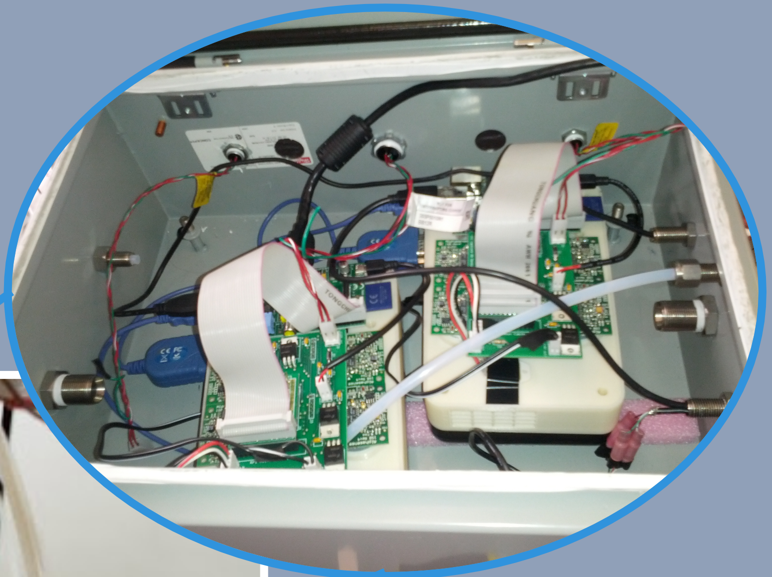
Our Node

Lab Instruments

# Running Experiments

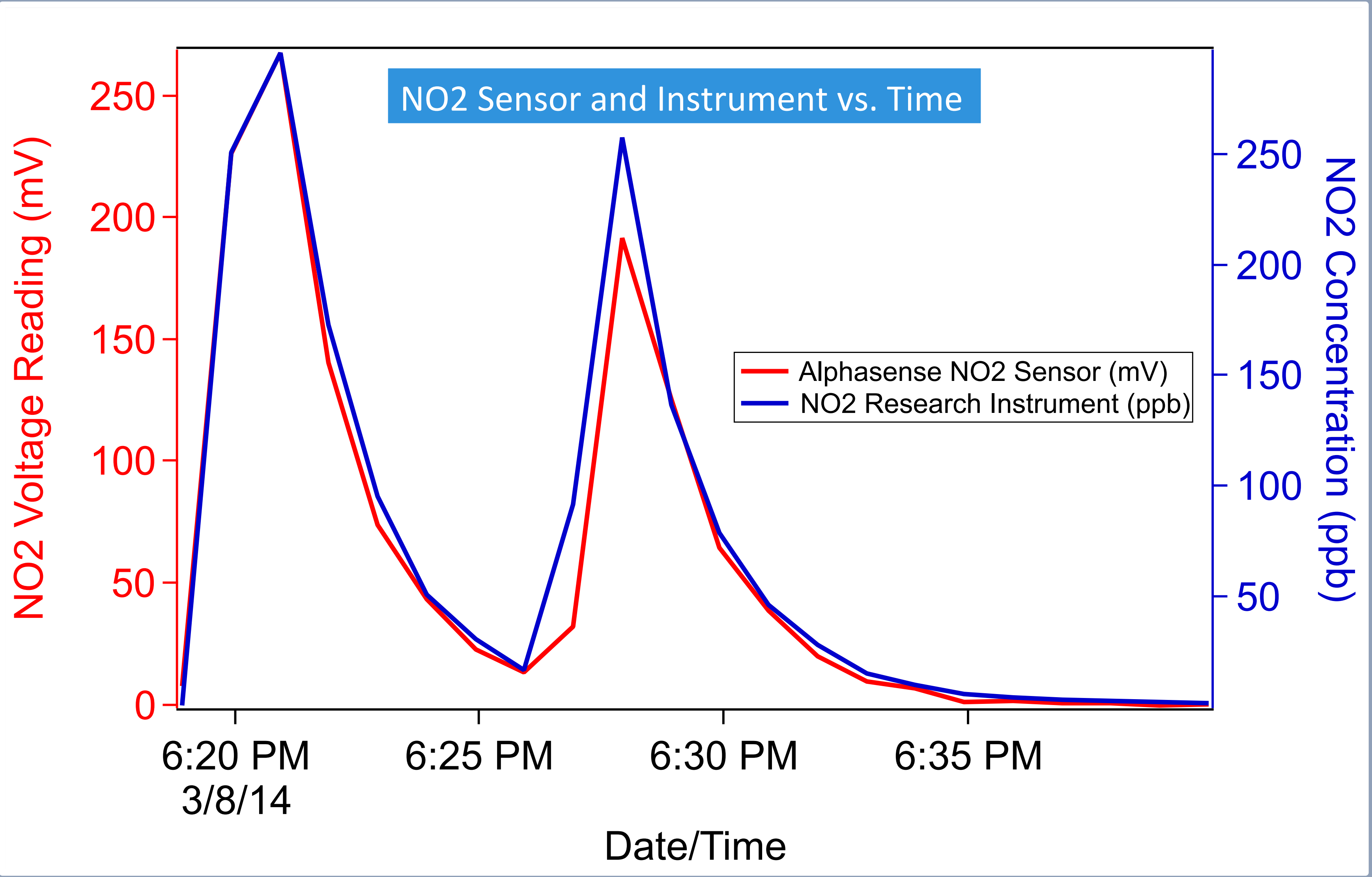
Inside the hood



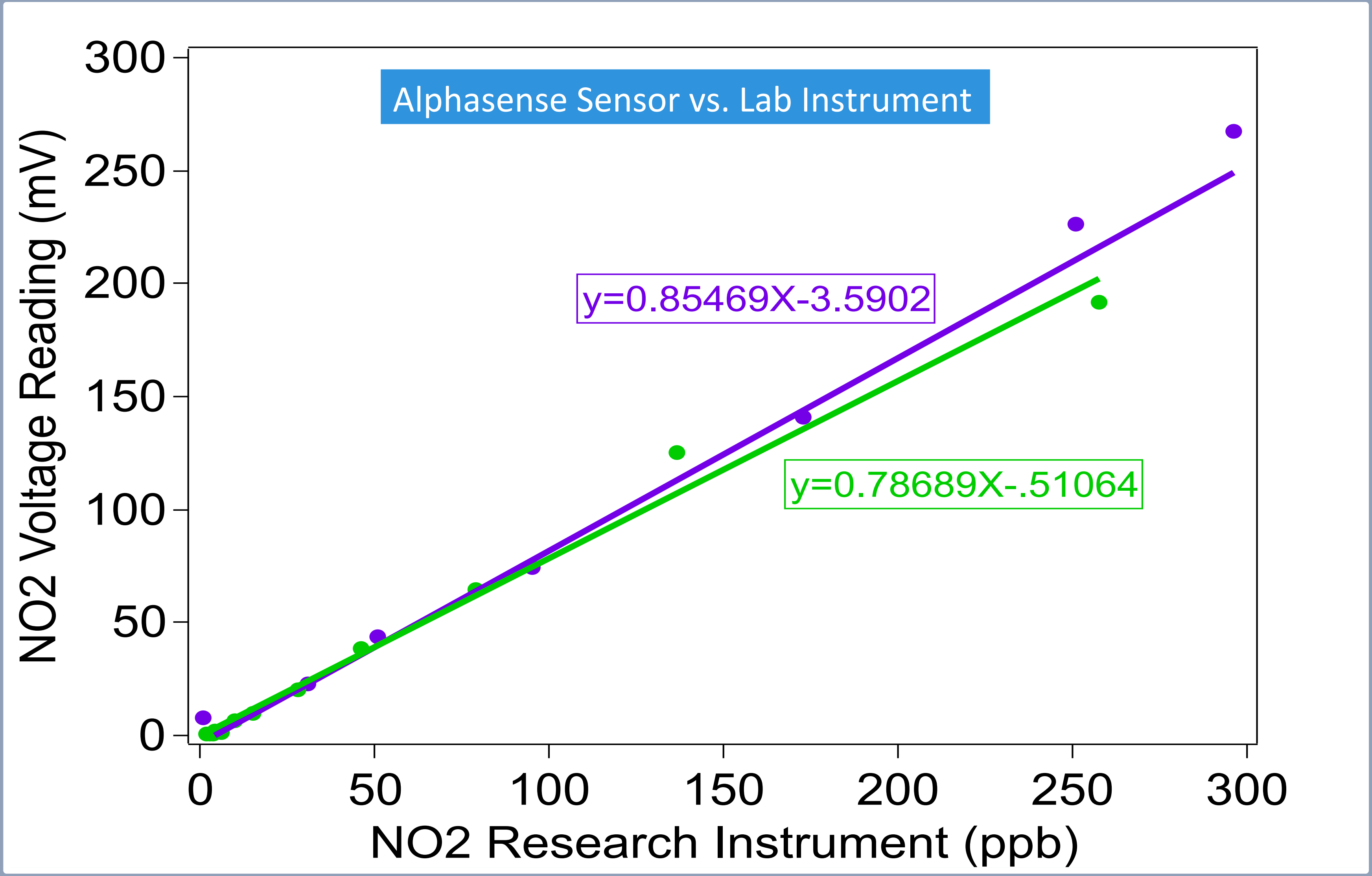



Inside the chamber

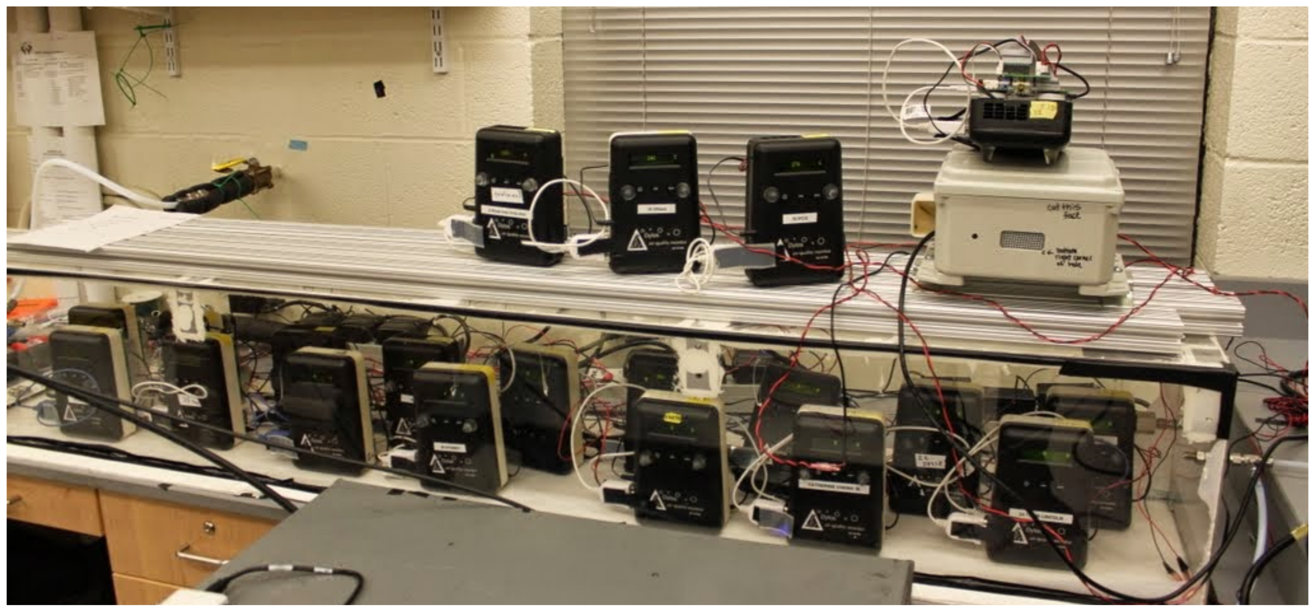
# Calibration Results



# Calibration Results

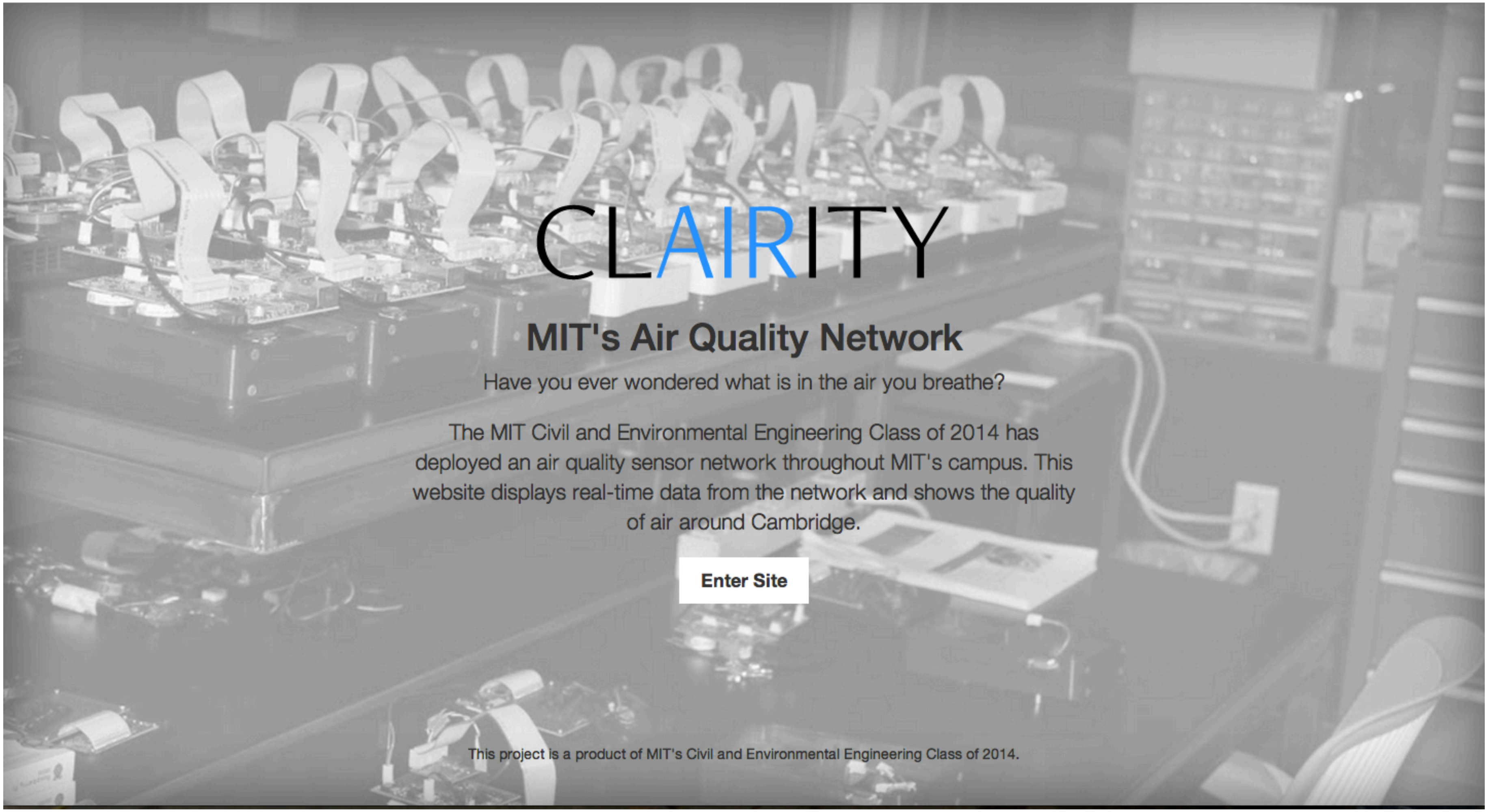


Ambient chamber

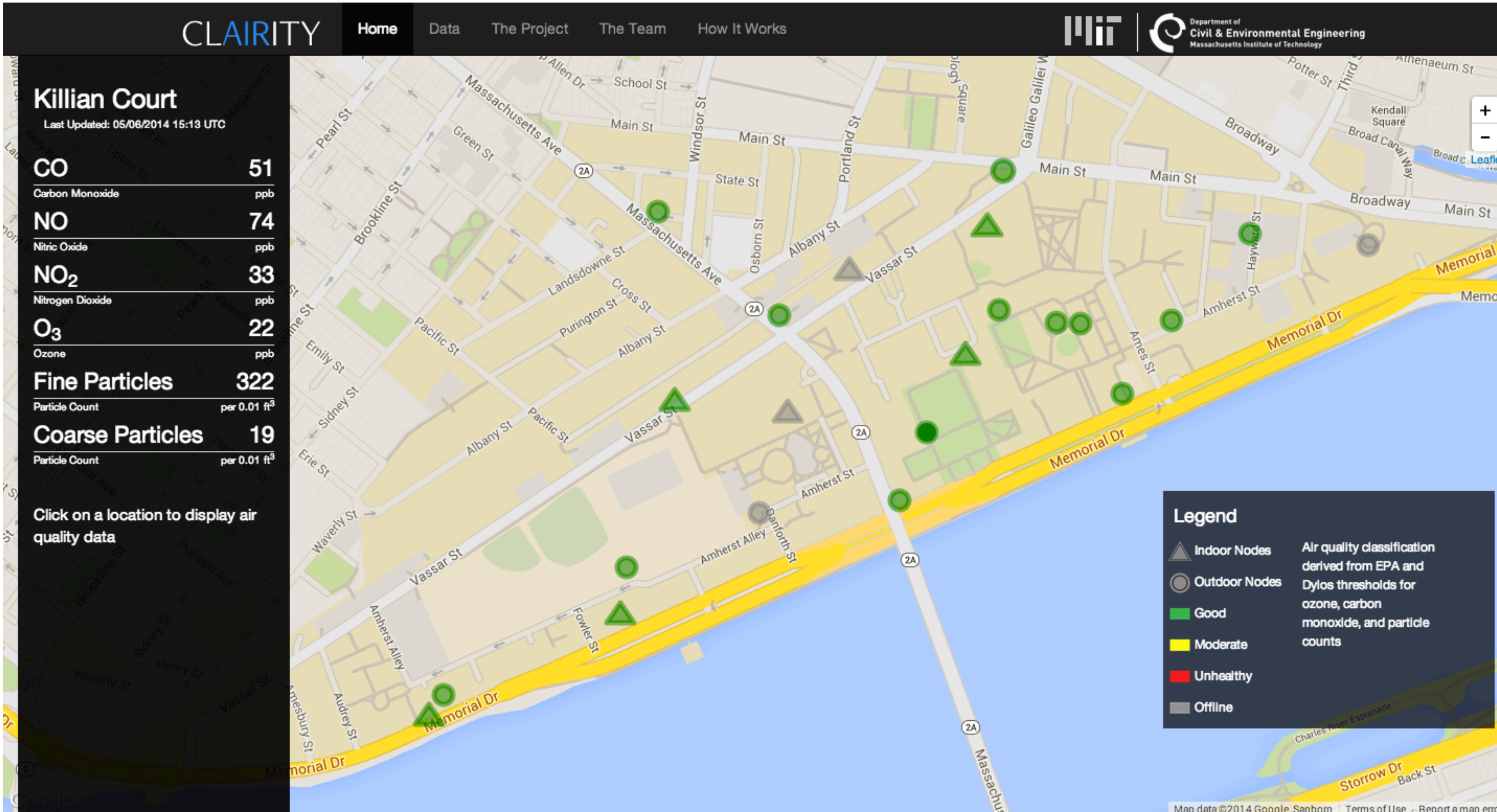


Co-located nodes

# Communicating our Data



# Communicating our Data



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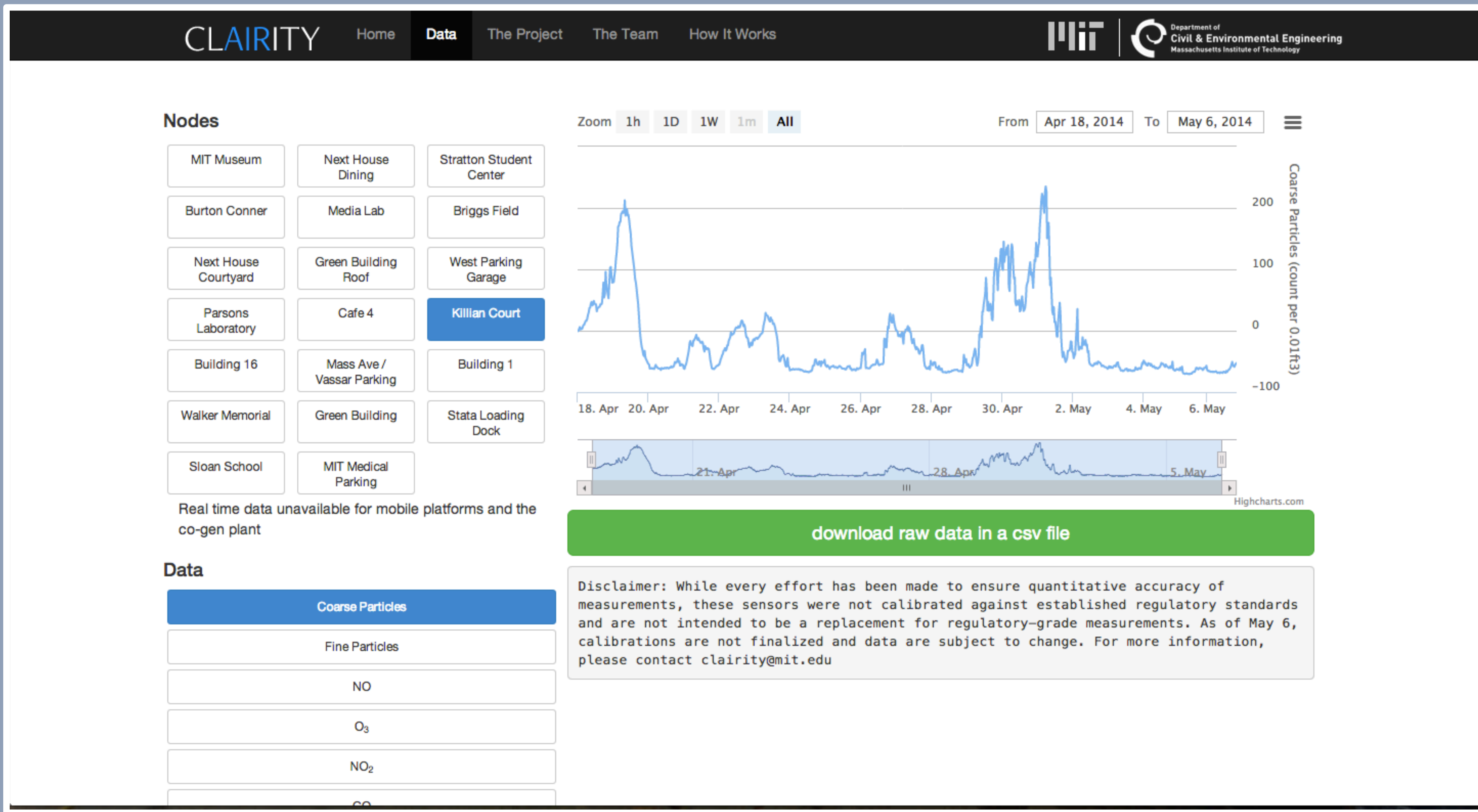


# Communicating our Data

## What are we measuring?

We are measuring five pollutants: nitric oxide, nitrogen dioxide, carbon monoxide, ozone, and particulate matter. The NOx group (nitric oxide and nitrogen dioxide) is emitted from automobiles, power plants, and turbines. Carbon monoxide comes from automobile exhaust and burning fuel. Particulate matter is the result of a wide range of manmade and natural sources, while ozone is the result of reactions between chemicals already in our air. Together, these pollutants paint a comprehensive picture of air quality impacts from the interaction of human activity with natural processes.

---

CO

### Carbon Monoxide

CO is an odorless, colorless gas that is highly toxic in when encountered in high concentrations! The main contribution of CO is vehicle exhaust but other sources include fuel combustion, fires, and volcanoes. Harmful health effects of CO occur when it enters the bloodstream through the lungs and binds to hemoglobin, reducing the amount of oxygen that reaches the bodys' tissues and organs.

NO

### Nitric Oxide

Nitric Oxide is colorless and odorless, and of the nitrogen oxides (NOx) emitted, NO is the primary pollutant. While NO is non-toxic by itself, it quickly converts to NO2 in the air.

Learn More

$NO_2$

### Nitrogen Dioxide

Nitrogen Dioxide (NO2) is strongly tied to the presence of O3 and particulate matter. The largest sources of NO2 are combustion processes, such as heating and power generation. Long-term exposure to NO2 has been linked to adverse respiratory effects.

Learn More

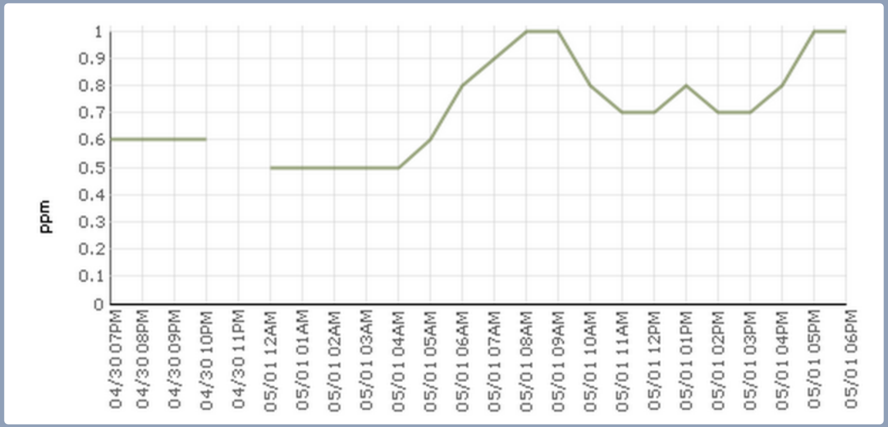
# How Does Our Network Compare?

As compared to current air quality systems, our network:

- shows higher resolution
  - sampling frequency
  - node concentration
- is more cost effective
- has increased public accessibility to data
  - download data
  - real-time data

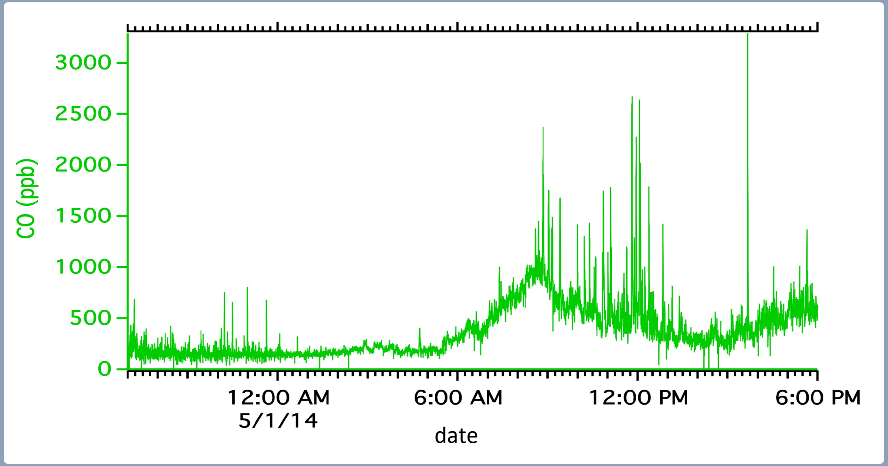
# Sampling Frequency

## Graph of CO Concentration Over Time




MassDEP Network

every hour

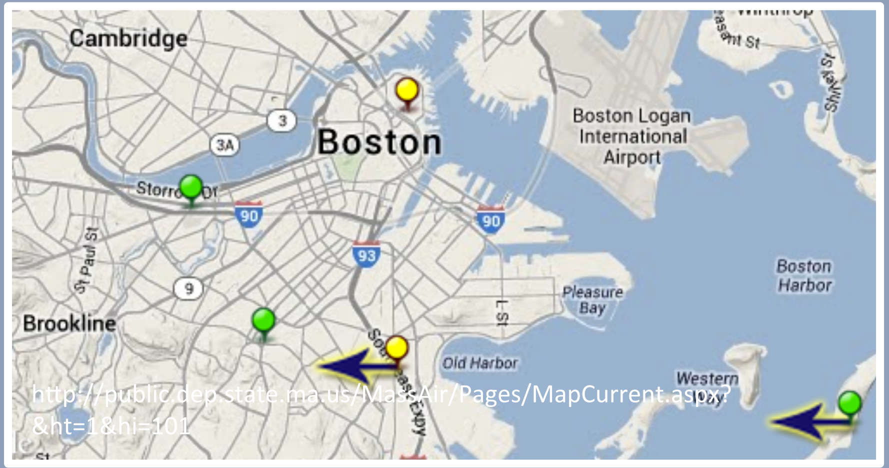



CLAIRITY Network

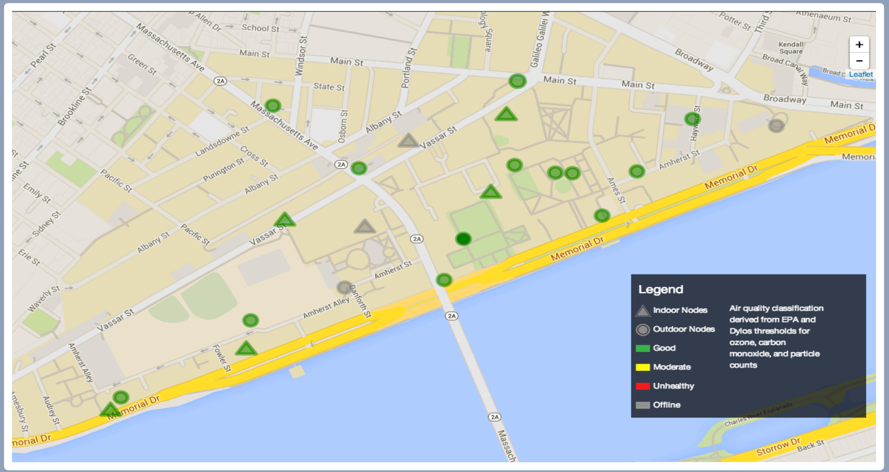
every 10 sec

# Node Concentration

MassDEP Network




CLAIRITY Network



# Node Concentration

| MassDEP | | CLAIRITY | |
|---|---|---|---|
| 57,344 | acres (Boston) | 168 | acres (MIT Campus) |
| ÷ 5 | stations | ÷ 24 | nodes |
| 11,468 | acres/station | 7 | acres/node |

# How Does Our Network Compare?

As compared to current air quality systems, our network:

- shows higher resolution
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# Cost Effective

## MassDEP

~ $100,000 per station

× 5 stations

~ $500,000 total

\>>

## CLAIRITY

~ $1500 per node

× 24 nodes

~ $36,000 total

# How Does Our Network Compare?

As compared to current air quality systems, our network:

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  - node concentration
  - sampling frequency
- is more cost effective
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  - download data
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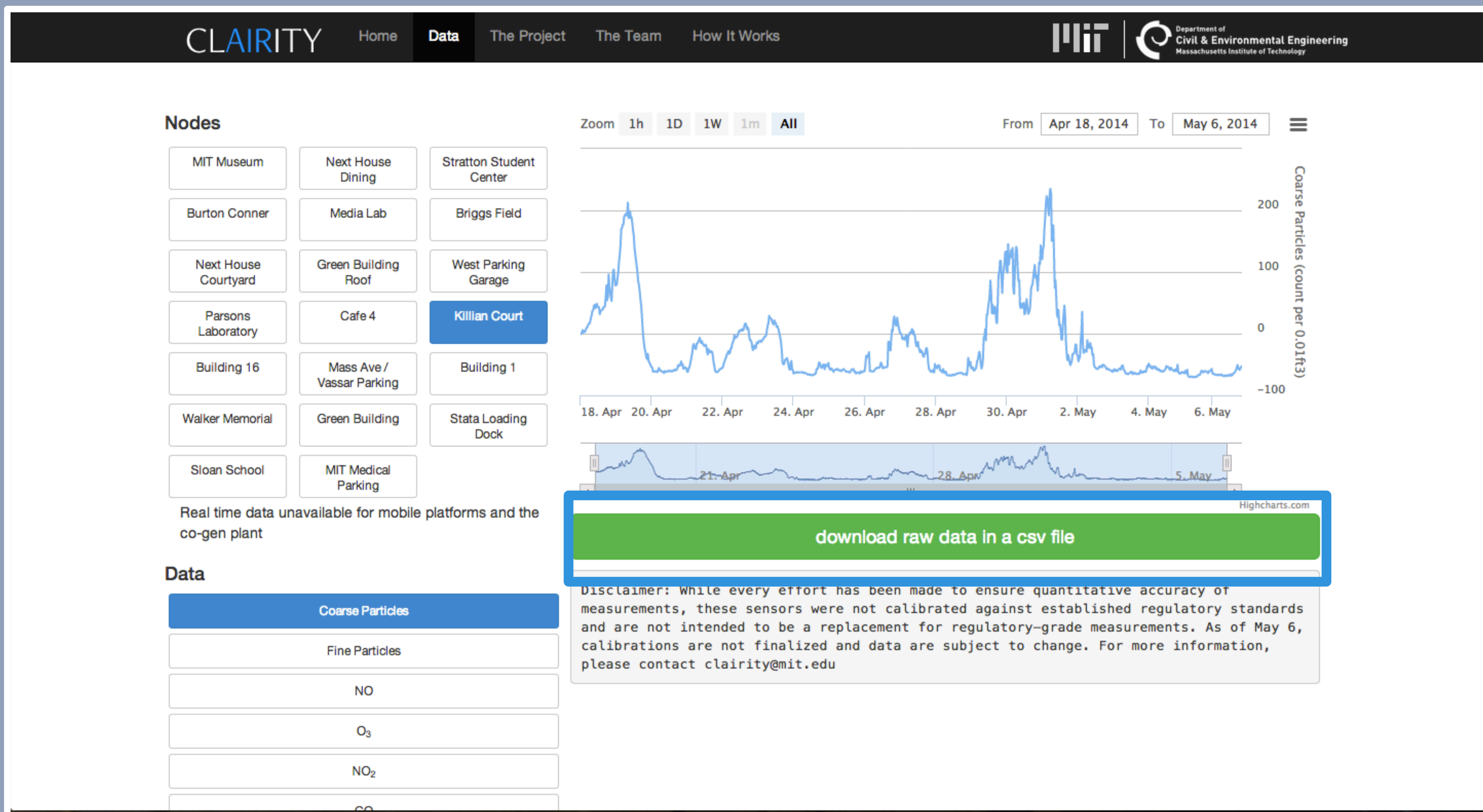
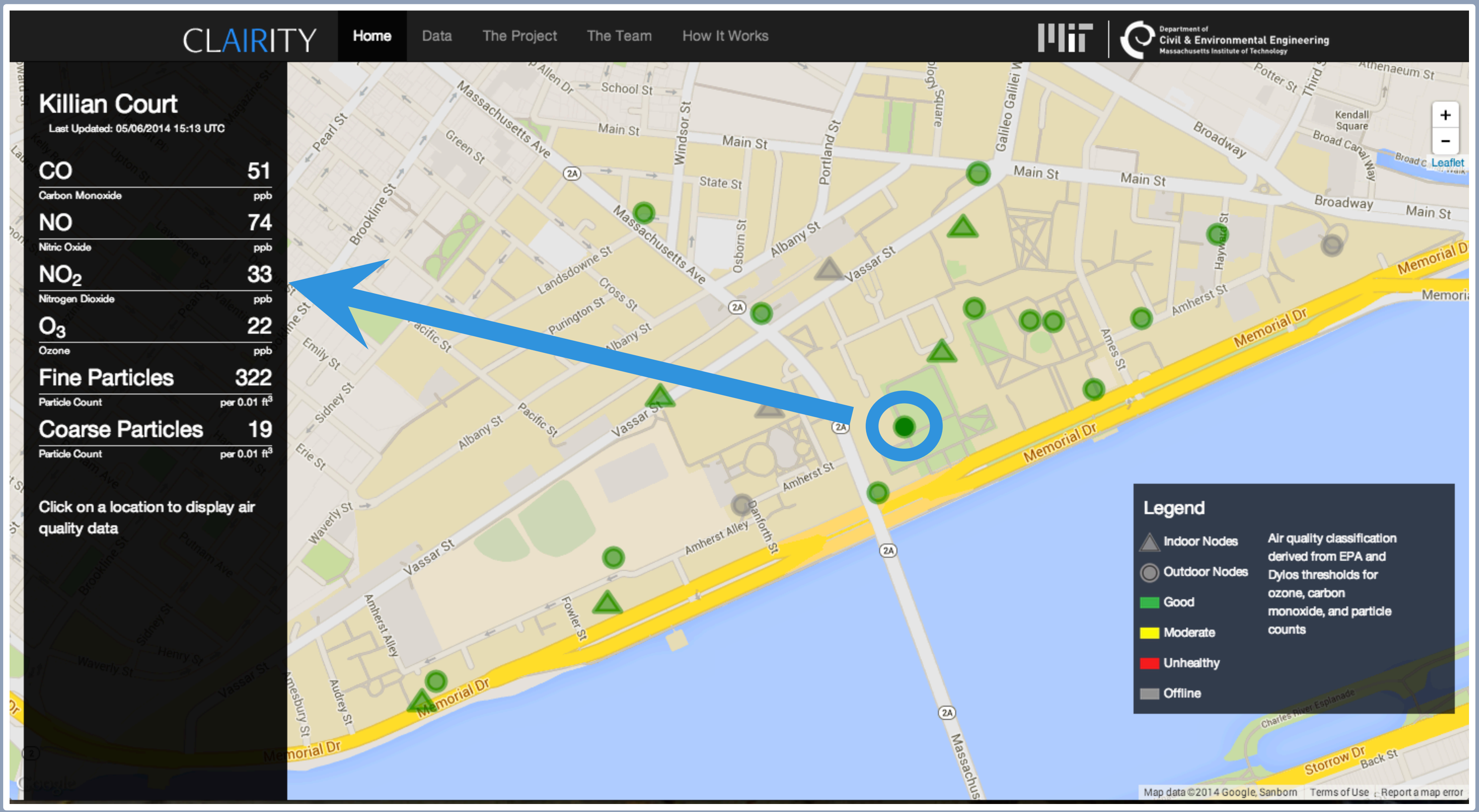
# Download Data



# Real-Time Data



# To Summarize…

24 Nodes

6 Pollutants

10 Second Resolution

Easily Accessible Data & Graphs

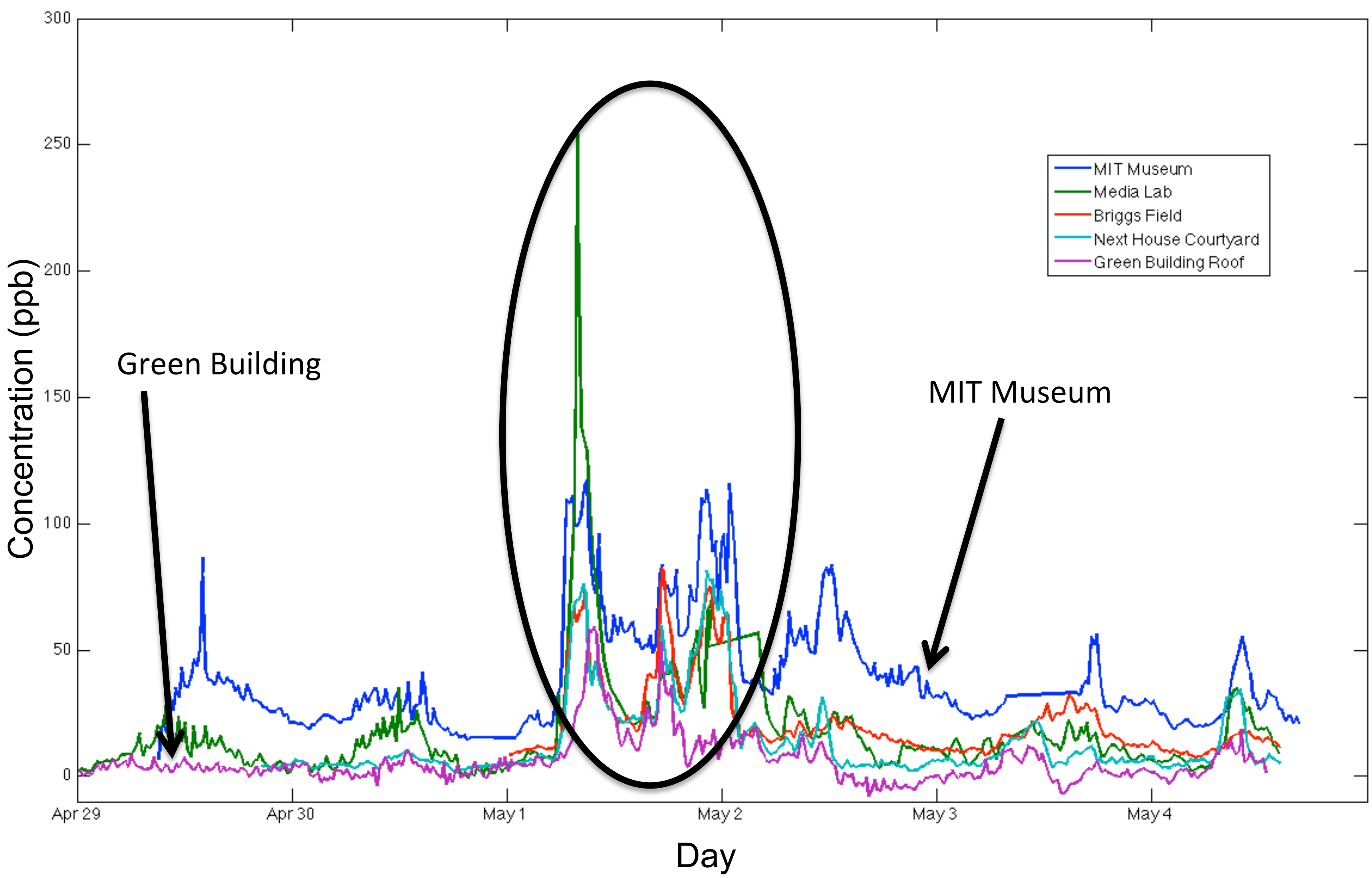
# Data Analysis

Understanding diurnal trends

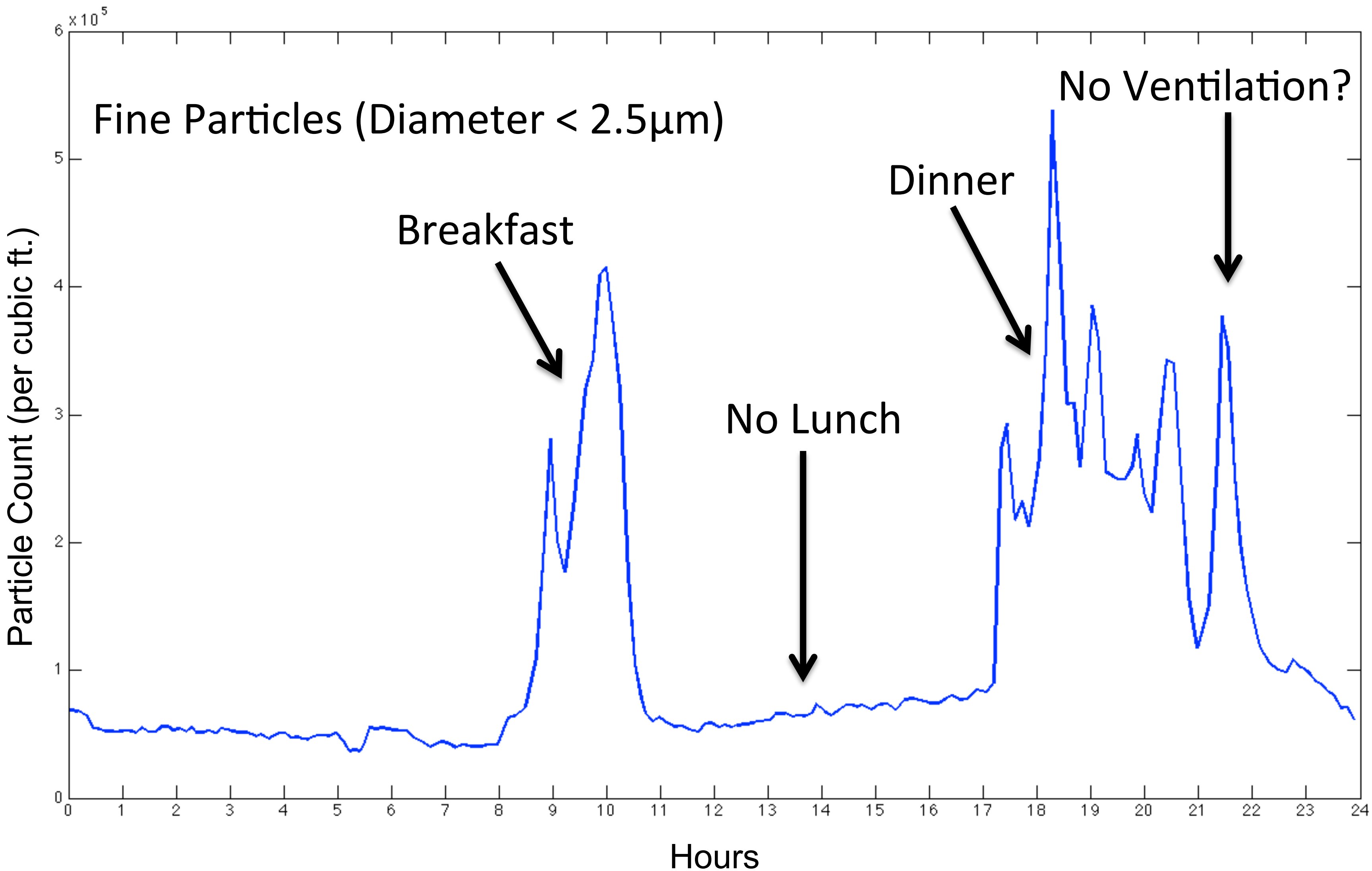
Pinpointing sources of pollution

Air quality comparison across locations

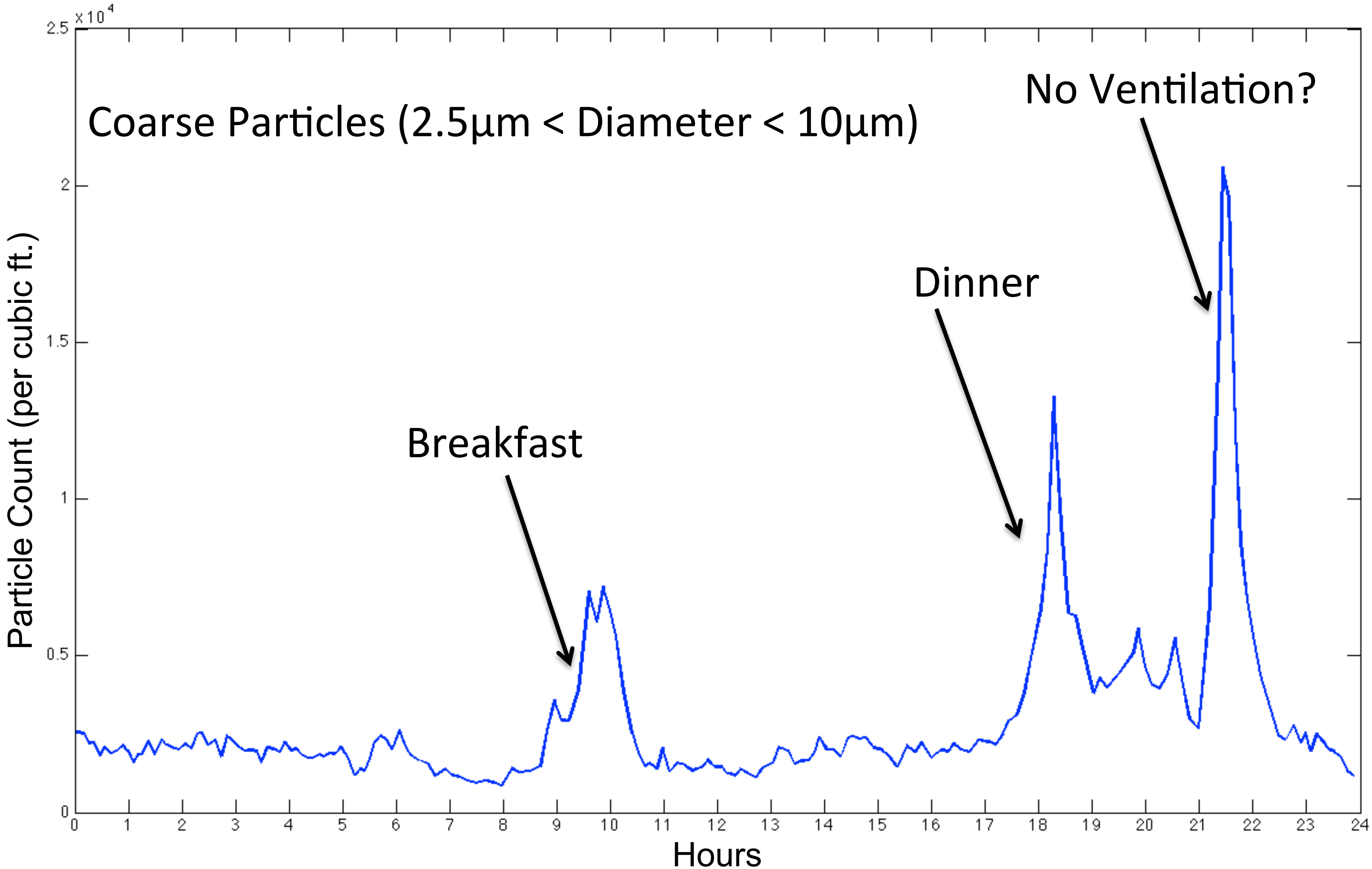
# Outdoor NO Concentration



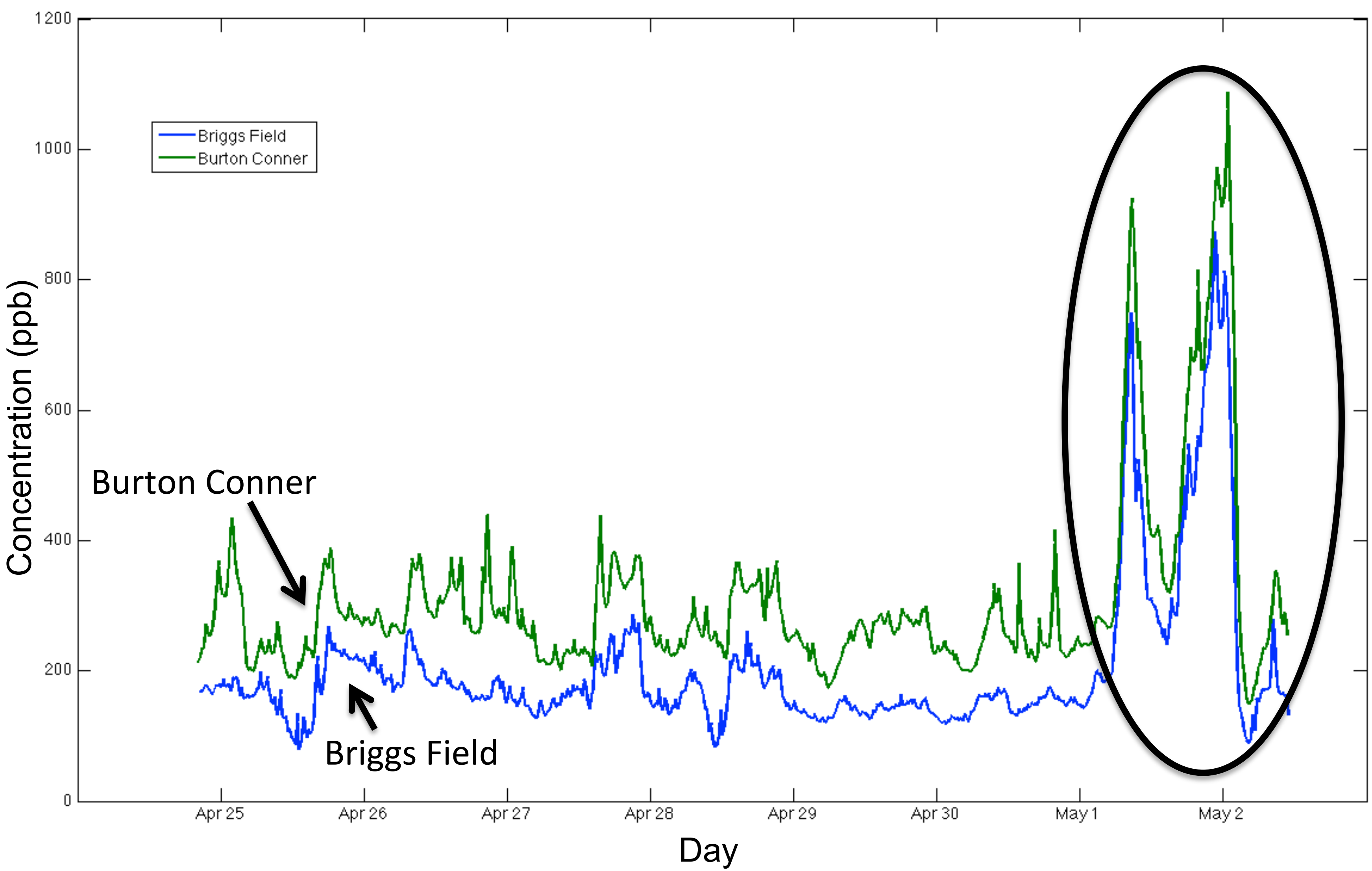
# Next House Dining



# Next House Dining



# Burton Conner vs. Briggs Field – CO



# Expanding CLAIRITY

- Pollutant origins
- Pollutant distribution
- Monitor dangerous levels
- Smart Cities

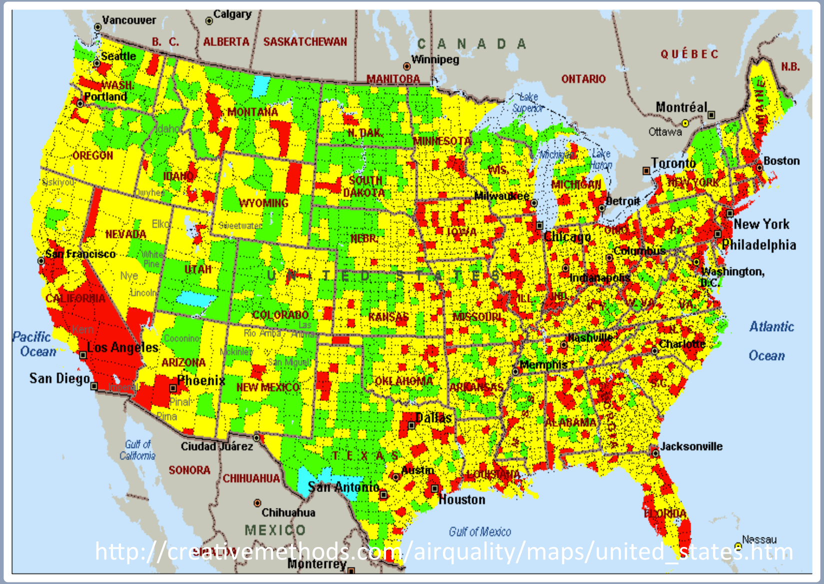
# Expanding CLAIRITY

- Pollutant origins

MIT.nano

# Expanding CLAIRITY

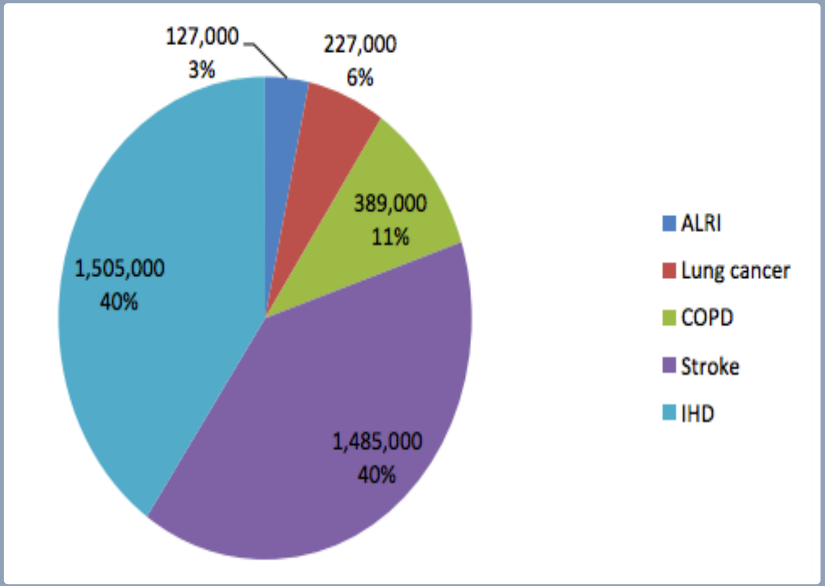
- Pollutant distribution

# Expanding CLAIRITY

- Monitor dangerous levels

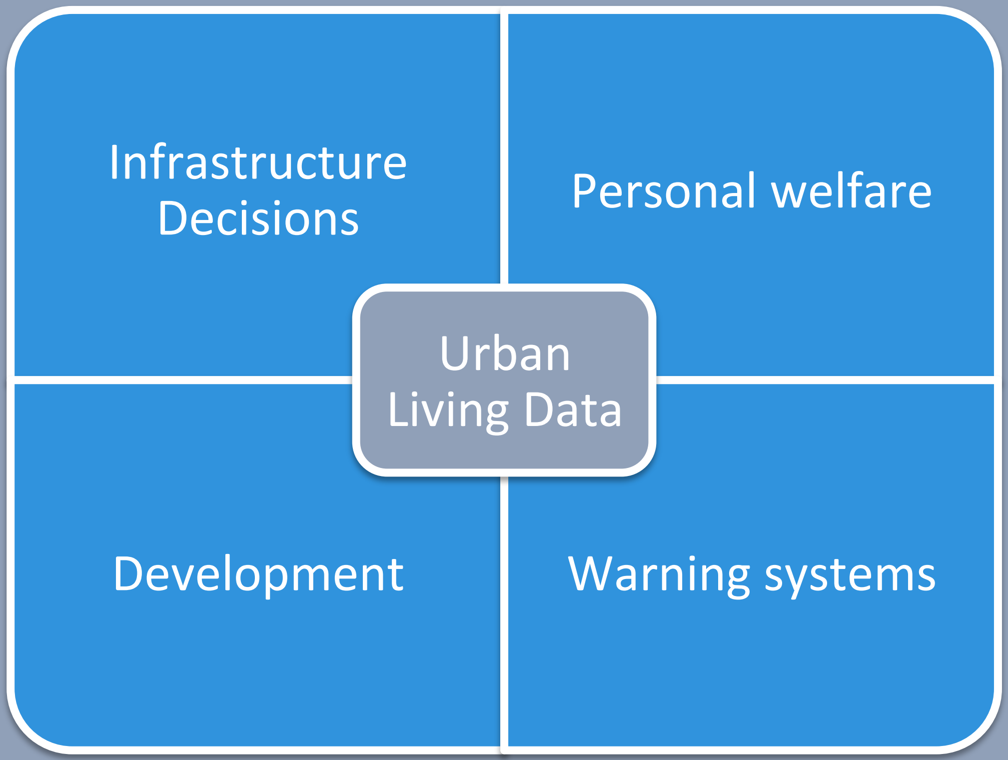
Deaths Attributable to Ambient Air Pollution (2012)

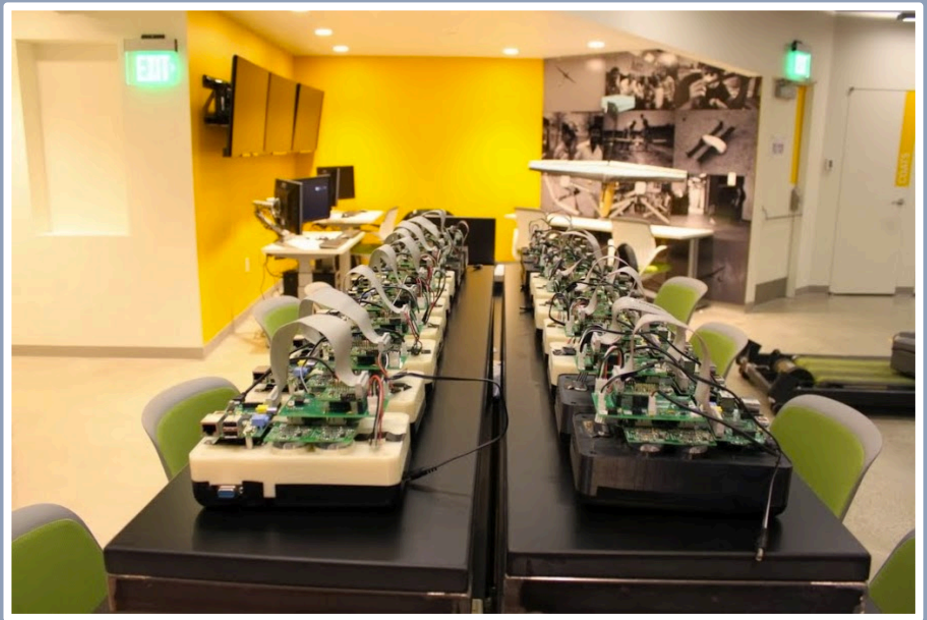



*ALRI: Acute Lower Respiratory Disease*
*COPD: Chronic Obstructive Pulmonary Disease*
*IHD: Ischaemic Heart Disease*
*From: who.int*

# Expanding CLAIRITY

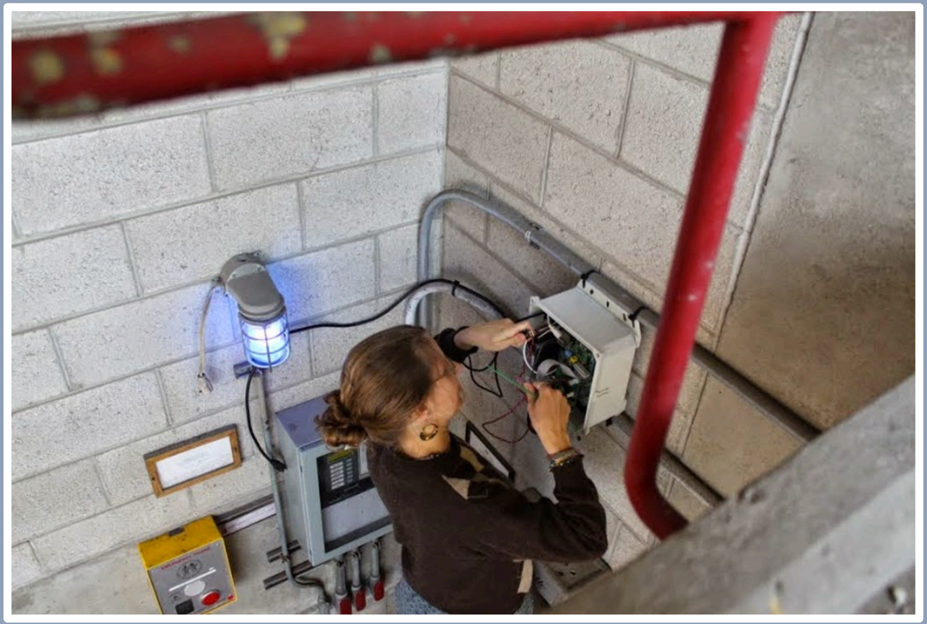
- Smart Cities





EXIT
EXIT

MIT



CLAIRITY
Air Quality Sensor
CEE Capstone Project
Questions, concerns, or to report an issue:
clairity@mit.edu
Civil & Environmental Engineering

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