Application of a Novel Sensor for Traffic-related Indoor Air Pollution

Jennie Cox

PhD Student

Environmental and Occupational Hygiene

Department of Environmental Health

College of Medicine

University of Cincinnati

Traffic Related Air Pollution (TRAP)

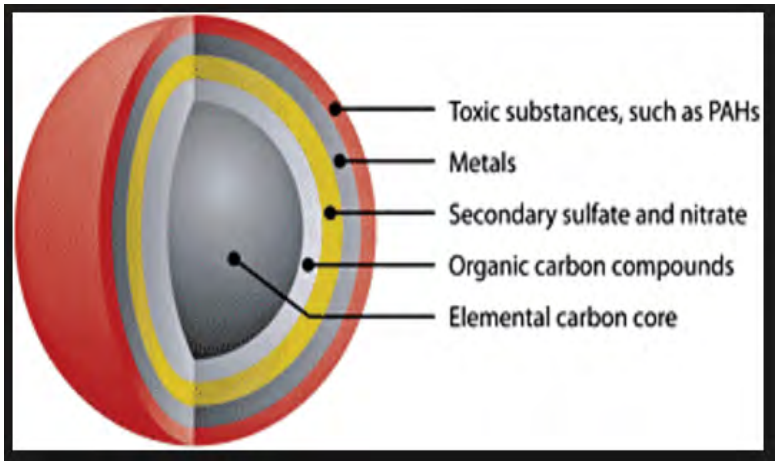
Traffic Related Air Pollution (TRAP) emitted by gasoline and diesel-fueled compression engines

- Highly complex mixture of gases and vapors composed of
  - Elemental Carbon
  - NOx
  - Particulate Matter (PM)
  - Volatile Organic Compounds (VOC)
  - Polycyclic aromatic hydrocarbons (PAH)

- Major Source of ambient PM2.5

  ~25% Particulate Matter from fuel combustion is derived from diesel exhaust particles

Diesel Exhaust Particle



(http://amicuscuria.com/wordpress/?p=685)

UNIVERSITY OF Cincinnati

Indoor Air Quality

- **Infiltration of outdoor particles**
  - Important source of indoor air pollution
- Almost 70% of U.S. workers are employed in non-industrial, non-agricultural indoor settings
  - (40 hours a week in office buildings)
- Infants and children spend more than 80% of their time indoors (Heinrich 2011)

- 30% to 45% of people in large North American cities are likely to be inside one or more exposure zones
  - Exposure zone, is within a range of up to 300 to 500 meters from a major road and the area most highly affected by traffic emissions
- Approximately 11.3 million people (or 3.7% of US population) live within 150 meters of a major highway
- Exposure to traffic air pollution, results in an elevated risk of adverse health outcomes (CDC, 2013).

UNIVERSITY OF Cincinnati

Health Effects

Traffic-related air particulates

- Exposure to traffic-related air popllution (TRAP) is linked with reduced respiratory health in both public and worker populations.
- National Institute of Occupational Safety and Health (NIOSH) - diesel exhaust a potential occupational carcinogen (NIOSH, 1988)
  - Noncancerous health effects:

    immunologic, respiratory, and cardiovascular effects.
- At lower levels
  - Mediators of allergic and inflammatory responses (cytokines, chemokines, immunoglobulins, and oxidants)

UNIVERSITY OF Cincinnati

National Occupational Research Agenda (NORA)

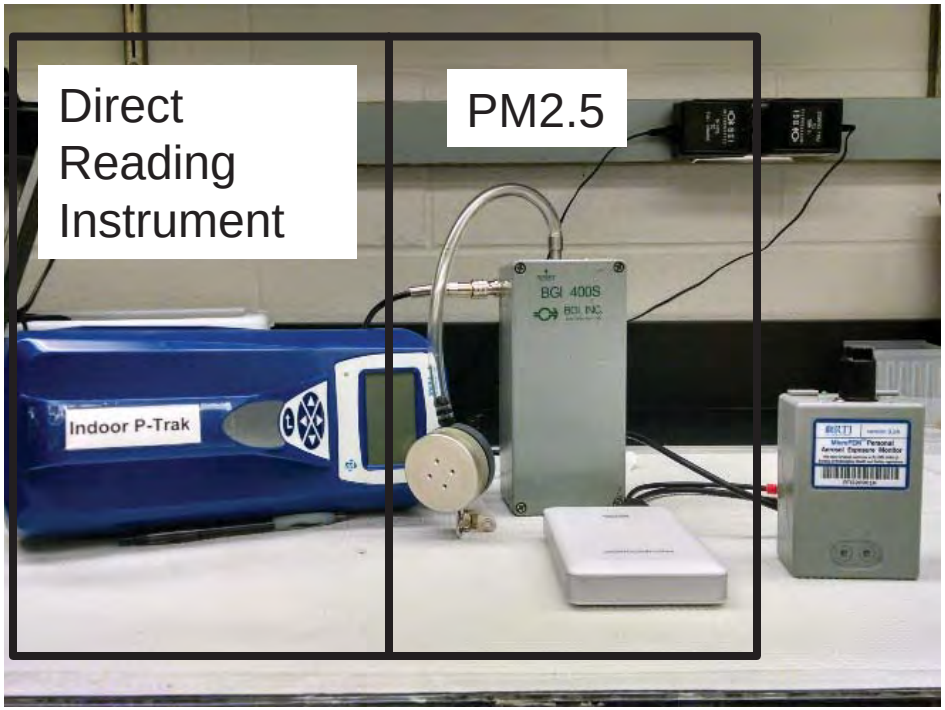
- In 1996, NORA's Indoor Environment Team (IET) began a nationwide research effort to identify and implement health-protective features and practices in buildings.

- In 2002, the NORA IET estimated that modest improvements in indoor environments could prevent respiratory infections or exacerbations of asthma or allergies among 6 to 10 million workers annually.

- This project aligned with the future goals for the NORA IET which called for improved methods for measuring exposures and better understanding of the reduction of indoor exposure through environmental interventions.

UNIVERSITY OF Cincinnati

Novel Air Sampling Device



PM2.5 and Direct Reading

Research Triangle Institute (RTI) Micro-personal exposure monitoring (PEM) device is capable of direct reading measurement of PM2.5 with a simultaneous collection to a Teflon filter.

UNIVERSITY OF Cincinnati

Hypothesis

- The central *hypothesis* is a correction factor for the real-time data of a novel device sampling device will provide a simple evaluation of traffic-related air pollution for indoor and outdoor locations within the Cincinnati region
  - Different regions of U.S. may need different correction factors depending on properties of particles

UNIVERSITY OF Cincinnati

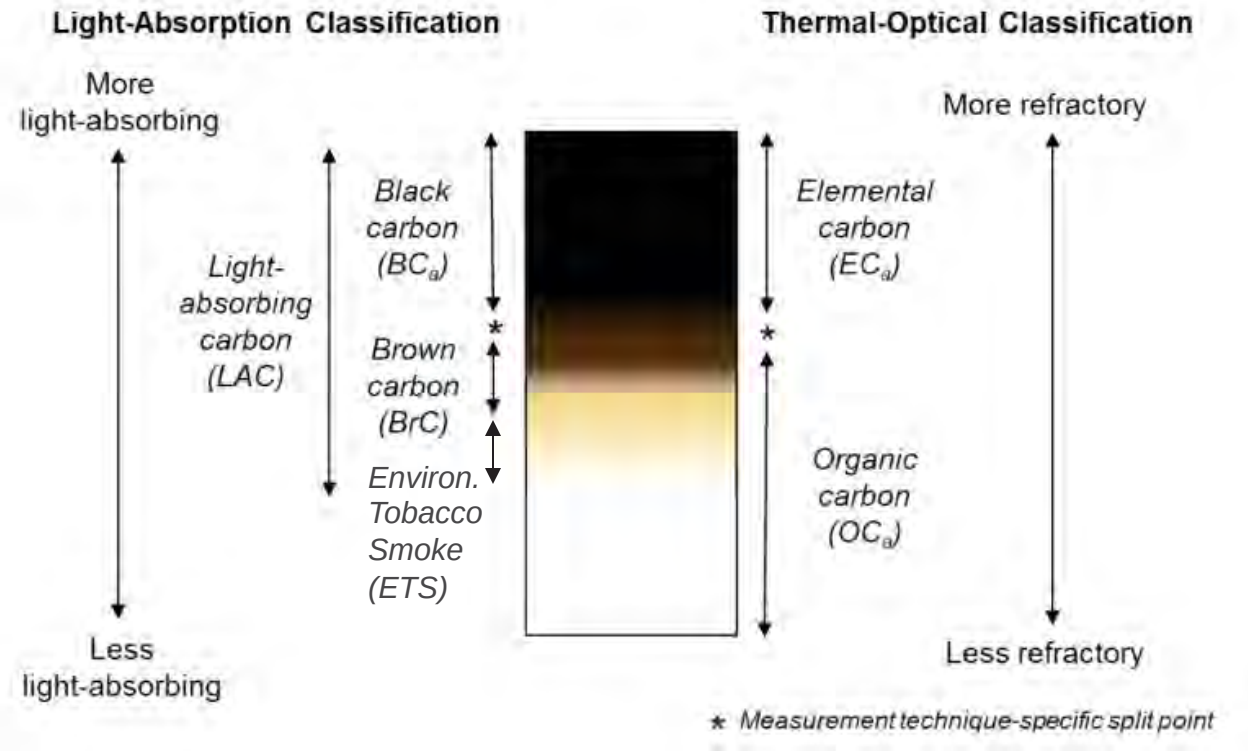
Collaboration

- U.S. Housing and Urban Development (HUD) Healthy Homes Technical Studies (HHTS) Grant
  - Efficiency of HEPA air purification in reducing traffic-related particle exposures in the homes of asthmatic children residing near major traffic sources
  - Recruitment of homes and coordination of sampling
- RTI International
  - MicroPEM devices provided at no cost

UNIVERSITY OF Cincinnati

Black Carbon Analysis

- Teflon filter can be used for assessment of PM2.5 mass, black carbon (BC), brown carbon (BrC) and environmental tobacco smoke (ETS) without affecting the deposit using a multiwavelength optical absorption technique



Measurement of the Carbonaceous Components of Particles

UNIVERSITY OF Cincinnati

Specific Aims

Specific Aim 1:

- Determine the correction factor for the PM2.5 real-time data obtained using mass-based PM2.5 data in the Cincinnati region for indoor and outdoor air.

Specific Aim 2:

- Determine the association between the correction factor and the ratio between different carbon species.

UNIVERSITY OF Cincinnati

HUD HHTS Overview

Conduct a double-blind, placebo-controlled study in order to assess the efficiency of HEPA air purification for traffic-related pollutants in the homes of asthmatic children residing near major traffic sources.

Visit 1	Visit 2	One Month HEPA or Dummy	Visit 3	Visit 4
(48 hrs)			(48 hrs)	

UNIVERSITY OF Cincinnati

Sampling

- Indoor and Outdoor
- Pre-HEPA and Post HEPA
- 48 hours

UNIVERSITY OF Cincinnati

Specific Aim 1:
Correction Factor

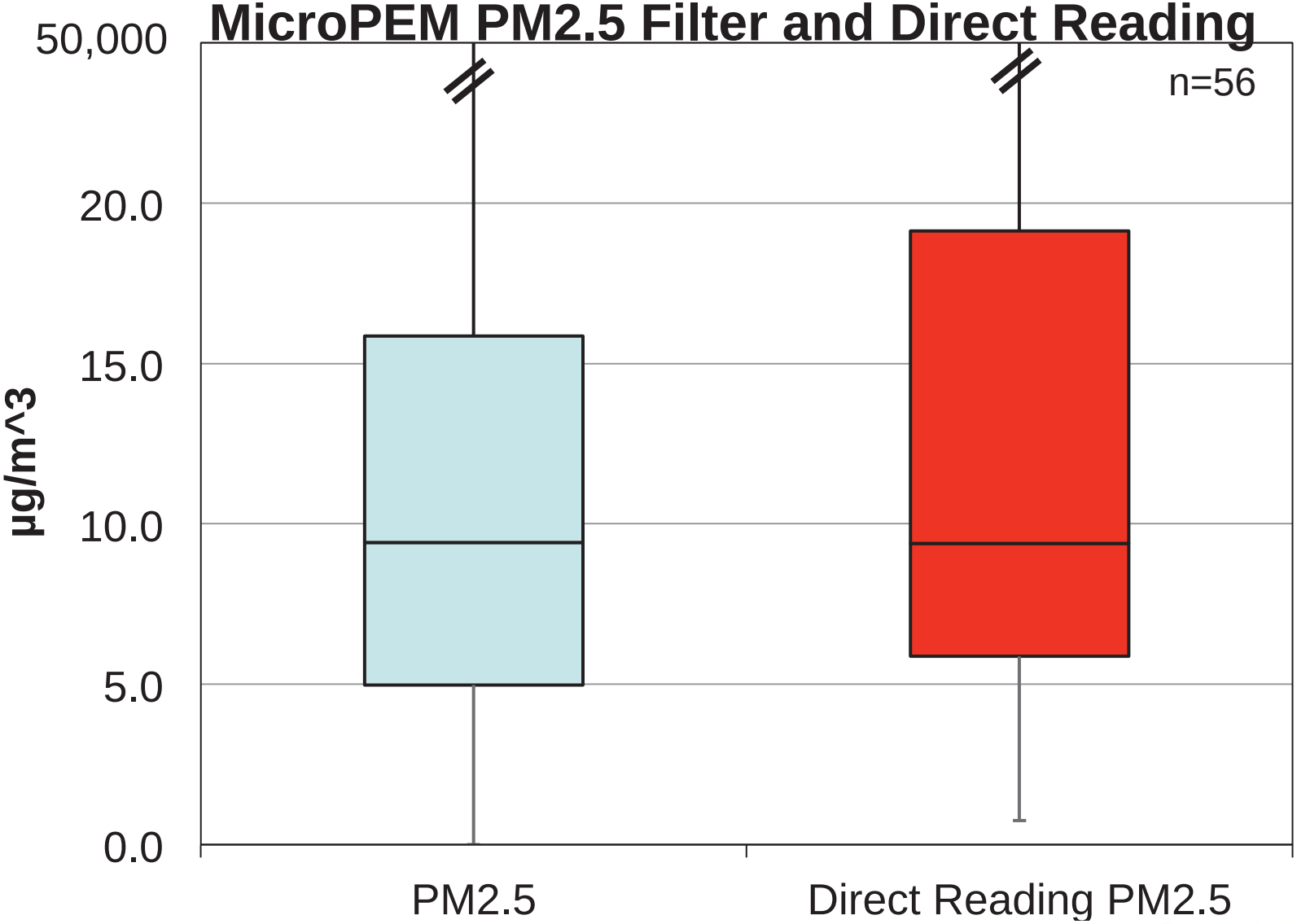
- Correction Factor = $\frac{\text{Filter PM2.5 mass}}{\text{Averaged Direct Reading PM2.5 Mass}}$

- Coefficient of Variation (CV) =

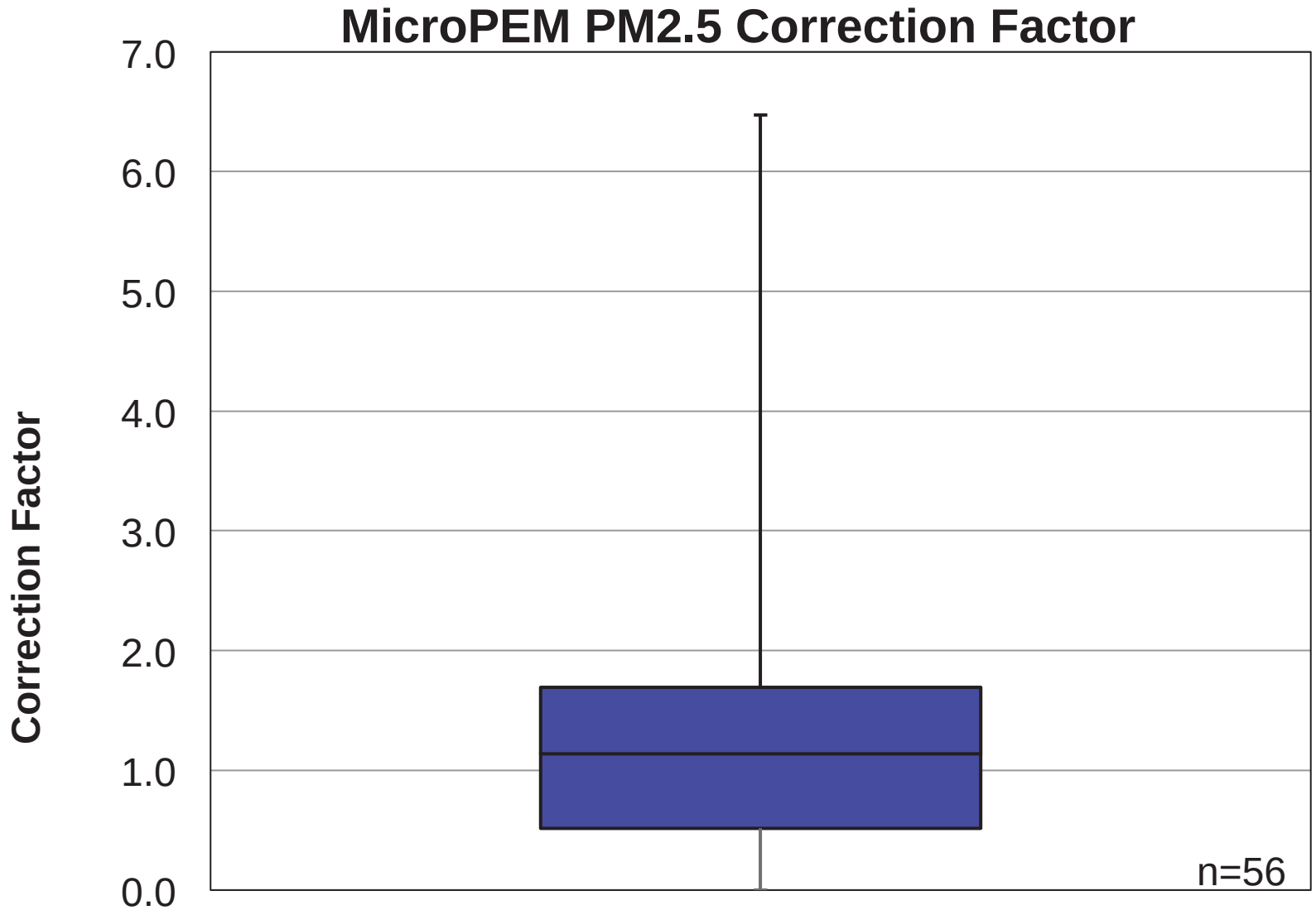
$$\frac{\text{Standard deviation of Correction Factor}}{\text{Average Correction Factor}}$$

- Goal: <20% CV

UNIVERSITY OF Cincinnati



UNIVERSITY OF Cincinnati



UNIVERSITY OF Cincinnati

MicroPEM Correction Factors

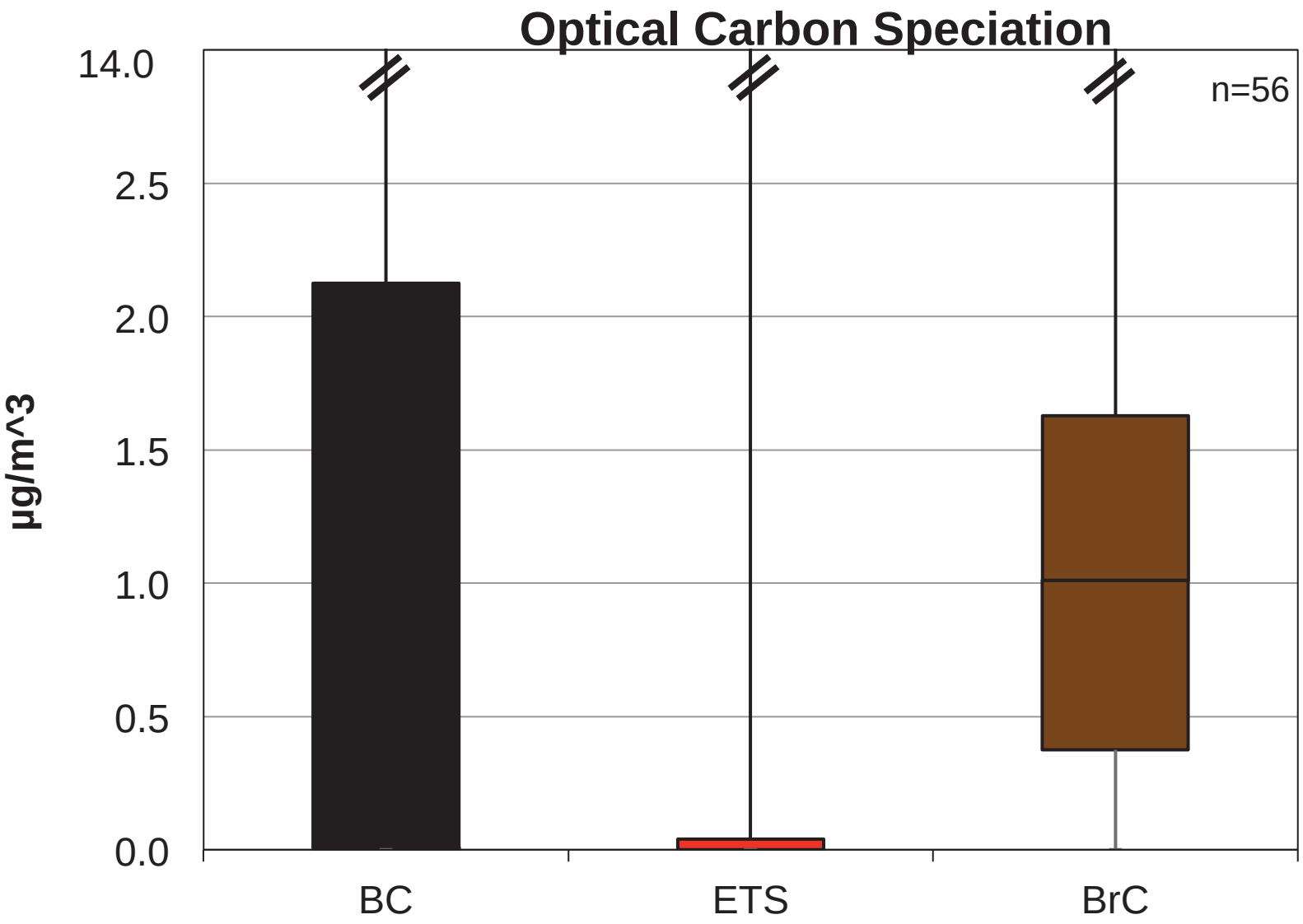
	Correction Factor	Standard Deviation	Coefficient of Variation
All Samples	1.5	1.5	100%
Indoor Samples	1.5	1.5	100%
Outdoor Samples	1.4	1.3	90%
Pre HEPA	1.6	1.7	100%
Post HEPA	1.3	1.4	110%

UNIVERSITY OF Cincinnati

Specific Aim 2:
Real-Time Data Independence

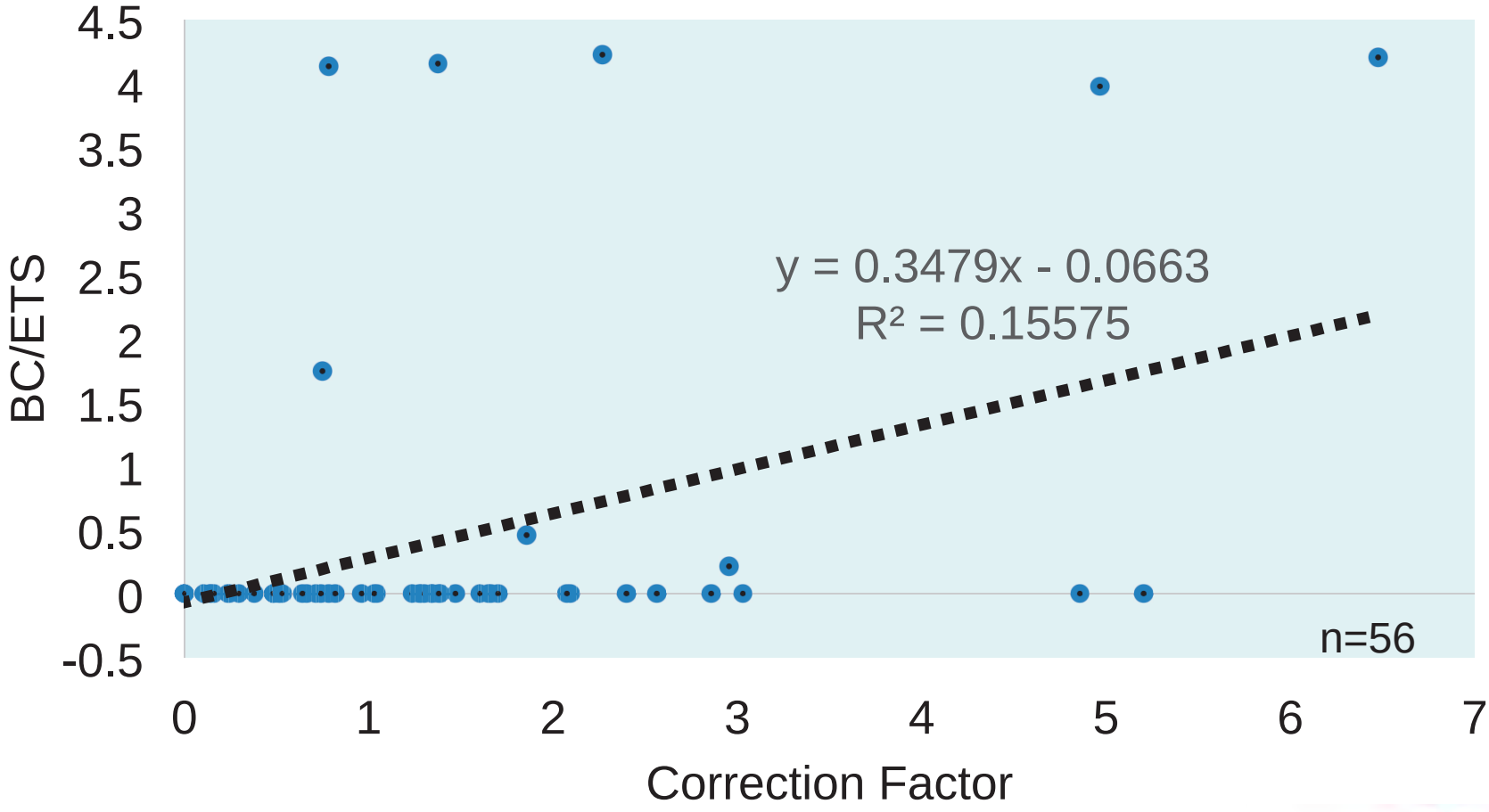
- Real-time data is independent on the amount of carbon species in the collected filter sample
- Slope of the regression line between the correction factor and the ratio of the carbon species (Black Carbon/Environmental Tobacco Smoke)
- Goal: Ratio will be within 20% from 0.
- If independent, the same correction factor can be used in all traffic situations (heavy or no traffic)

UNIVERSITY OF Cincinnati



UNIVERSITY OF Cincinnati

Linear Regression of Correction Factor and BC/ETS



UNIVERSITY OF Cincinnati

Conclusions

- Thus far the correction factor was not consistent to be applicable for all samples

- Slope of the regression line between the correction factor and the ratio of the carbon species (Black Carbon/Environmental Tobacco Smoke) was not within 20% from 0.

UNIVERSITY OF Cincinnati

Impact of Results

- MicroPEM will provide a easy and cost effective tool to monitor indoor air quality
- This data provides direction for the future:
  - Leave the device longer to have more reliable PM2.5 mass filter data due to the low volume of sample collection
  - Avoid rain/snow during outdoor sampling

UNIVERSITY OF Cincinnati

R2P Potential & Research to Future Funding

- Practicing Industrial Hygienists could potentially use this one device instead of multiple devices and with no laboratory analysis costs

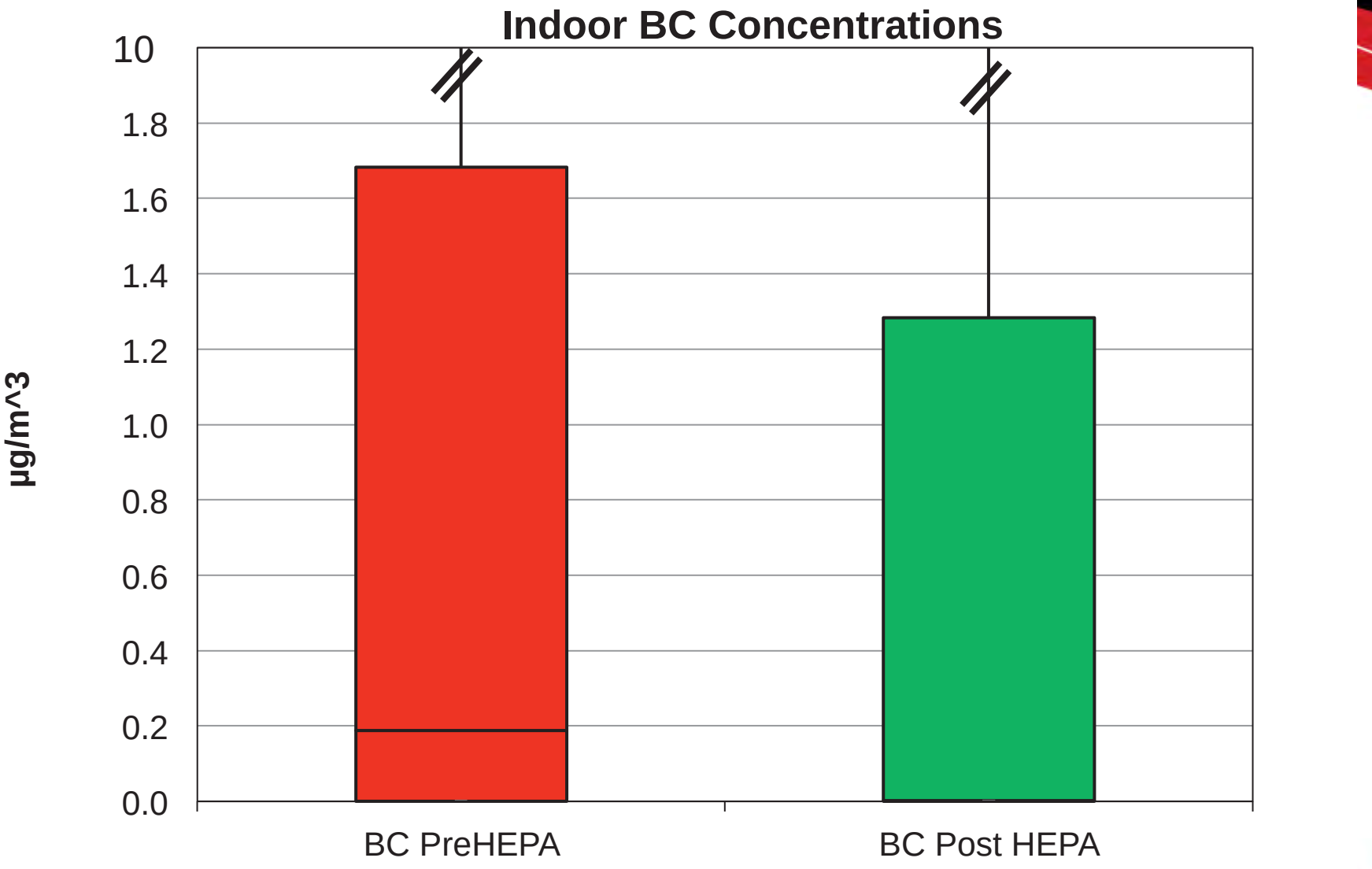
- Further research could include evaluating occupational locations for TRAP by using the MicroPEM at:
  - Older schools, offices, and manufacturing locations in high traffic areas could rely on open windows for ventilation, leading to increased exposure to outdoor air traffic-related pollution.

UNIVERSITY OF Cincinnati

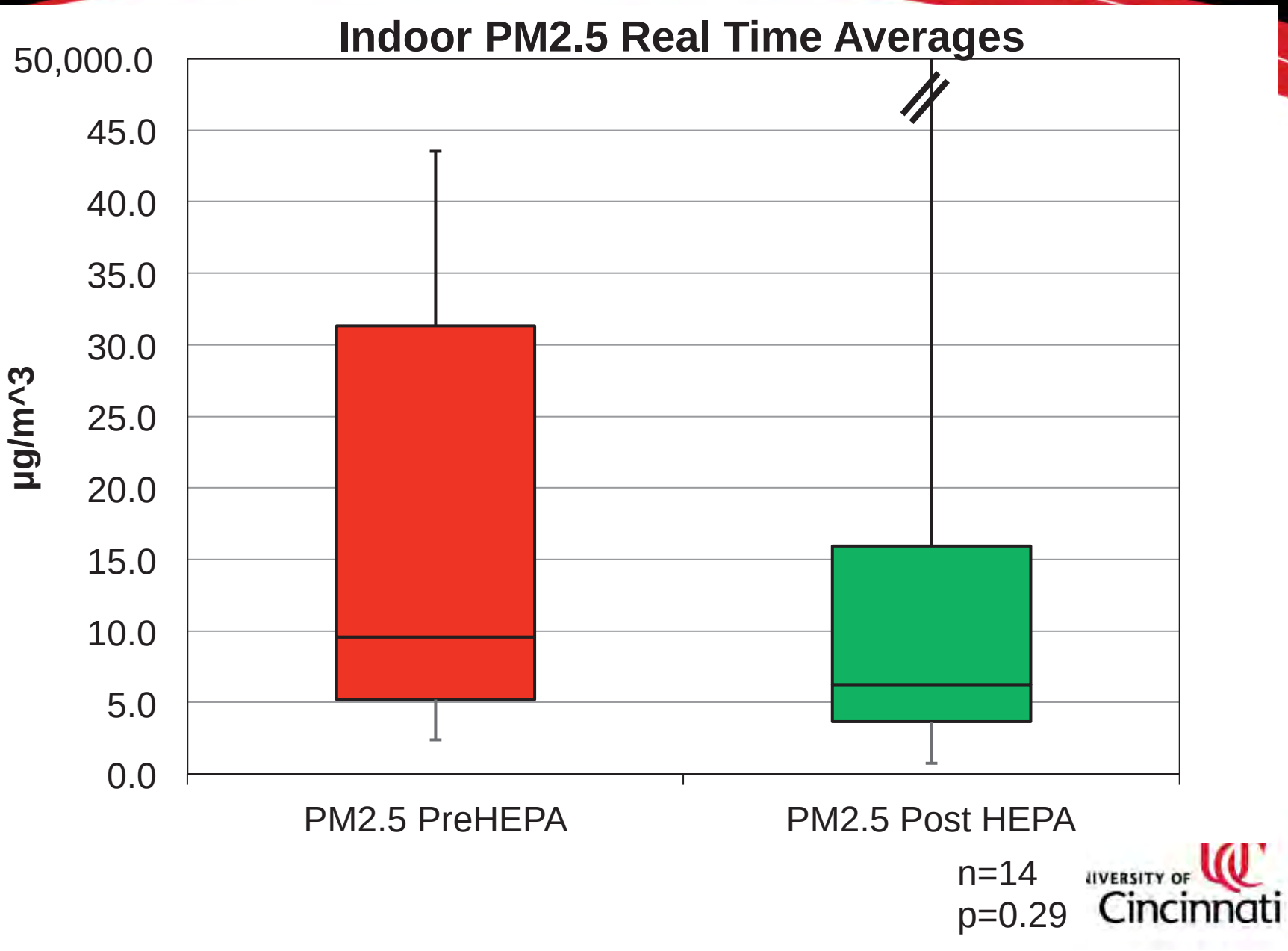
Thank you!

Any Questions?

UNIVERSITY OF Cincinnati

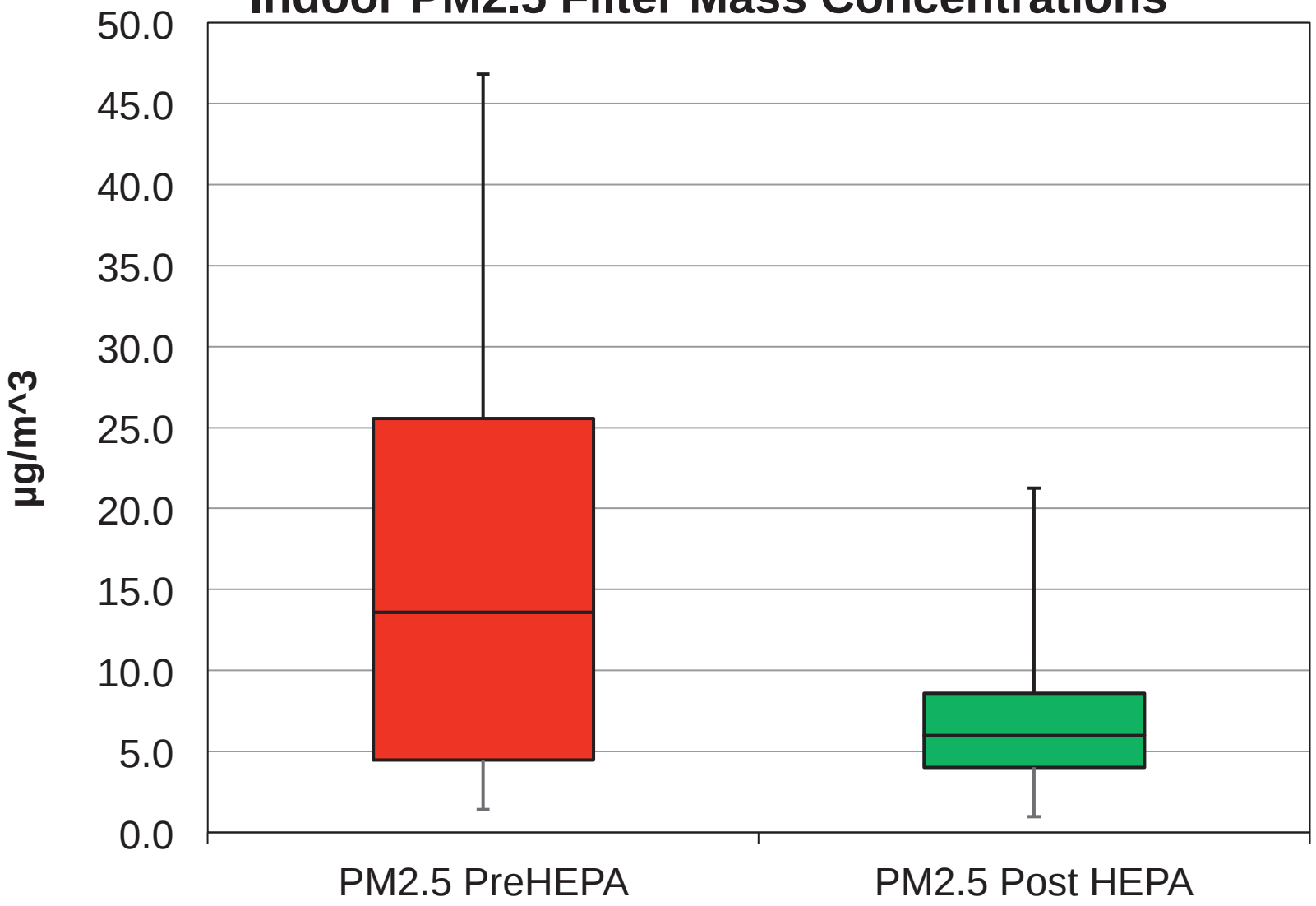


UNIVERSITY OF Cincinnati



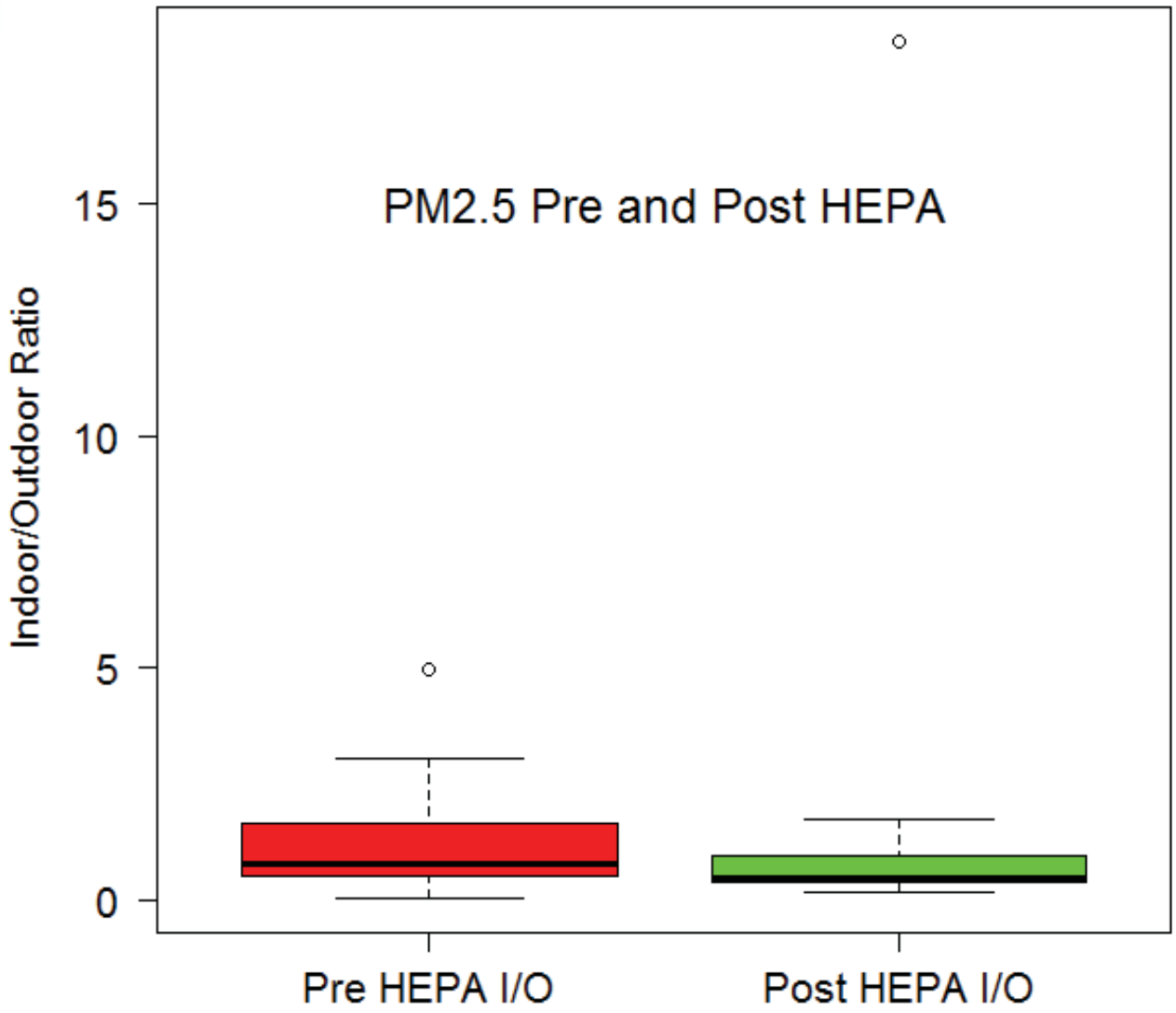
UNIVERSITY OF Cincinnati

Indoor PM2.5 Filter Mass Concentrations



n=14
p=0.07

UNIVERSITY OF Cincinnati



ERSITY OF Cincinnati

Common Air Leaks in a Building

UNIVERSITY OF Cincinnati

University of Cincinnati
17th Annual
Pilot Research Project
Symposium
October 13-14, 2016

Hosted by: The University of Cincinnati Education and Research Center
Supported by: The National Institute for Occupational Safety and Health. (NIOSH) Grant #: T42-OH008432

Main Menu:

Produced by Kurt Roberts Department of Environmental Health

University of Cincinnati
17th Annual
Pilot Research Project
Symposium
October 13-14, 2016

Pilot Research Training Program (PRP) Overview

Welcome to the University of Cincinnati Education and Research Center's (ERC) 16th Annual Pilot Research Project (PRP) Symposium on October 8-9, 201Welcome to the University of Cincinnati Education and Research Center's (ERC) 17th Annual Pilot Research Project (PRP) Symposium on October 13-14, 2016, held in the Auditorium of Proctor Hall, College of Nursing. The purpose of the PRP is to increase the research capacity of research trainees and young investigators in occupational health and safety and to encourage those in related disciplines to pursue occupational health and safety research.

Under the administrative direction of Dr. Amit Bhattacharya, research proposals are solicited and peer-reviewed annually from qualifying faculty and graduate students from the **University of Cincinnati and the following PRP partnering institutions – Air Force Institute of Technology, Bowling Green State University, University of Toledo – Health Science Campus, Central State University, Purdue University, University of Kentucky, Western Kentucky University, Eastern Kentucky University, Murray State University, Ohio University and Kentucky State University**.

At this symposium, the 2015-16 awardees will be presenting the results of their research and the 2016-17 awardees will make poster presentations of their proposed work. The keynote speaker on Thursday, October 13, 2016 is **Anita Schill, PhD, MPH, MA**, Senior Science Advisor to the Director and Co-Manager for the Total Worker Health® Program with the National Institute for Occupational Safety and Health (NIOSH), will deliver the keynote address on "**Advancing Well-Being Through Total Worker Health.**"

The University of Cincinnati's Education and Research Center is one of 18 such centers funded by the National Institute for Occupational Safety and Health (NIOSH) nationally. Dr. Tiina Reponen serves as the director of the ERC, which is based in the university's Department of Environmental Health within the College of Medicine. The purpose of the ERC is to train professionals in the didactic and research skills necessary to lead the occupational safety and health disciplines. Results of research are translated into action through an outreach program and shared with professionals and practitioners in the region via continuing education.

Since 1999, the PRP program has allocated over $1.3 million to support 222 pilot research projects. These projects have served as a catalyst in bringing over $34 million in additional research support to the region from sources independent of the PRP program, such as, the National Institute for Occupational Safety and Health (NIOSH), National Institutes of Health (NIH), United States

Department of Agriculture (USDA), National Science Foundation (NSF), and the Centers for Disease Control and Prevention (CDC). Additionally, the PRP has brought 47 new investigators from other fields of expertise to the area of occupational safety and health research.

Return to Main Menu