INDOOR AIR QUALITY & HEALTH

Session 3 - Thursday, Oct. 22, 2020

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www.ROCIS.org

2020 One Health One Planet™ Symposium

"One Health and the Air We Breathe"

Phipps Conservatory & Botanical Gardens Oct.19 - 23, 2020

Find this presentation here:

http://rocis.org/past-rocis-events

Outline

1. ROCIS, Why focus on particles?
2. Low Cost Monitoring Project
3. Reducing exposure

Frustration Alert! Lots of links & text

- Find this presentation here:
- http://rocis.org/past-rocis-events

ROCIS *(Rock-us) or (Raucous)* Reducing Outdoor Contaminants in Indoor Spaces

WWW.ROCIS.ORG

WHAT IS ROCIS ?

Our MISSION

A Southwestern Pennsylvania initiative to reduce the impact of exterior pollution in indoor spaces.

Why??

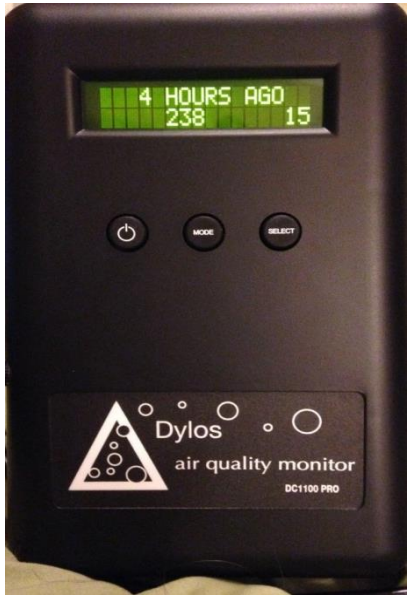
Most of our exposure *to outdoor pollution* happens IN buildings

http://www.iaqscience.lbl.gov

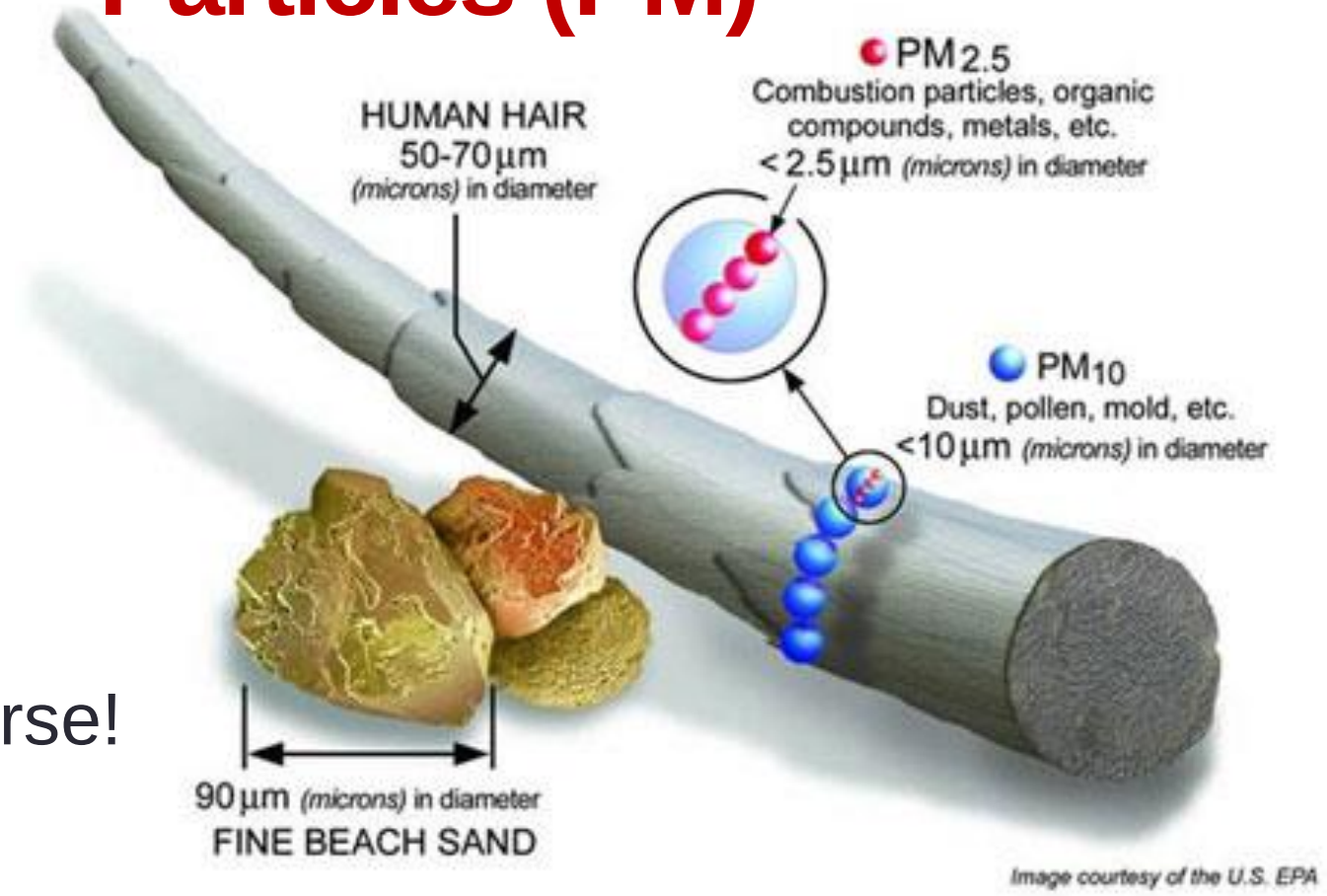
Focus on Particles

Also referred to as Particulate Matter (PM)

Particles (PM)



Dylos 1700
Our work horse!



$PM_{2.5}$: Particulate matter <2.5 µm in diameter

→ ROCIS LCMP Dylos: Particles > 0.5 µm

(1/100 of human hair!)

Health Concerns - Particles

- Particles differ in toxicity
- Can be adverse synergy with other co-pollutants
- Fine & Ultra-Fine particles can be vehicles to increased exposure of toxic contaminants such as SVOCs & metals
- Our premise: "***Precautionary principle"*** – avoid or minimize exposure

Outdoor Plus Indoor!

ROCIS LCMP
Low Cost Monitoring Project

- Started 5 years ago
- Mostly homes, some work places
- 350 participants

ROCIS
Low Cost Monitoring Project (LCMP)

Objectives

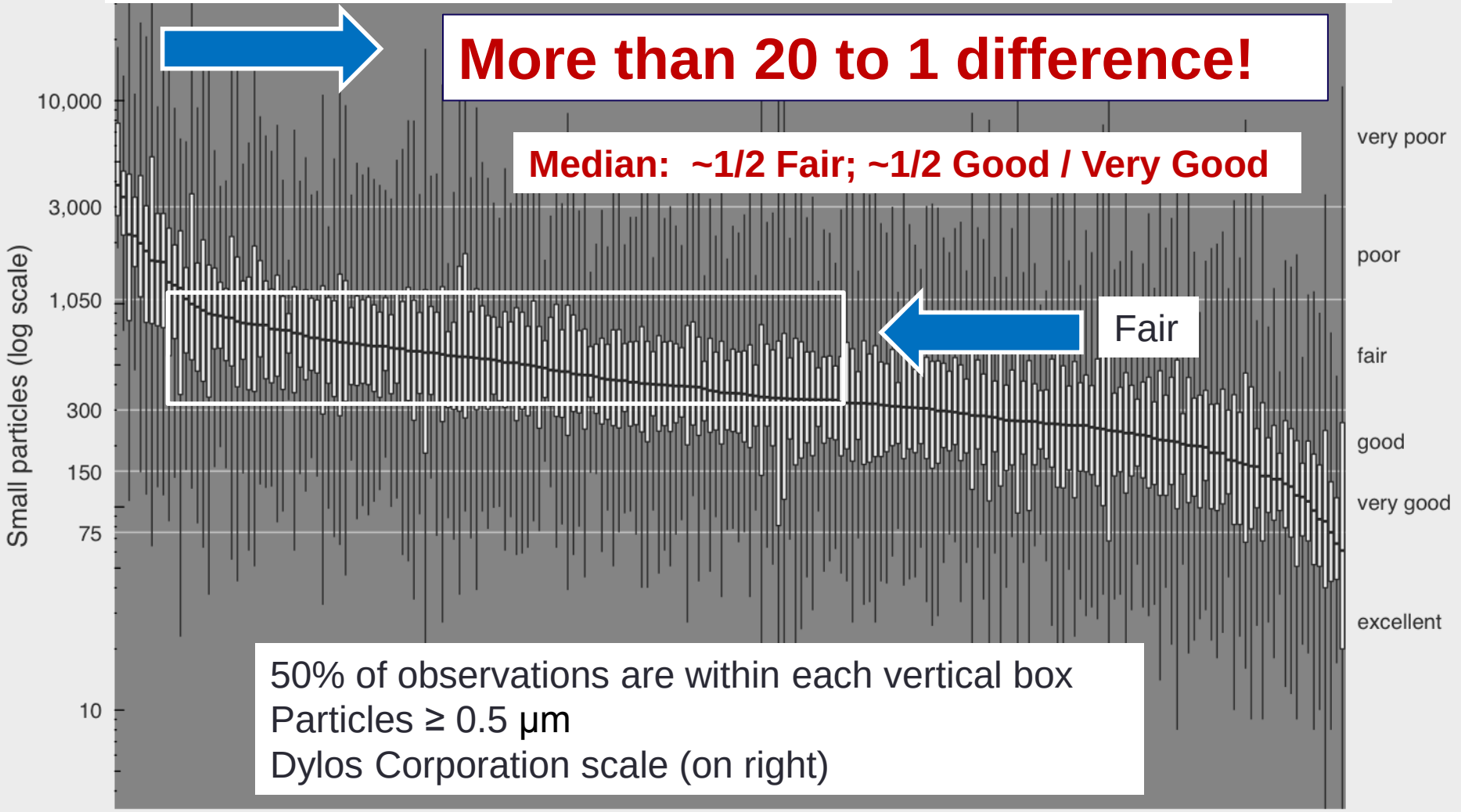
1) **Learn how low-cost air monitors *empower* occupants**

2) **Examine the *impacts* of outdoor on indoor air**

3) **Explore *interventions* to improve indoor air quality**

4) ***Develop champions!!***

Indoor Particle Distribution – All Sites



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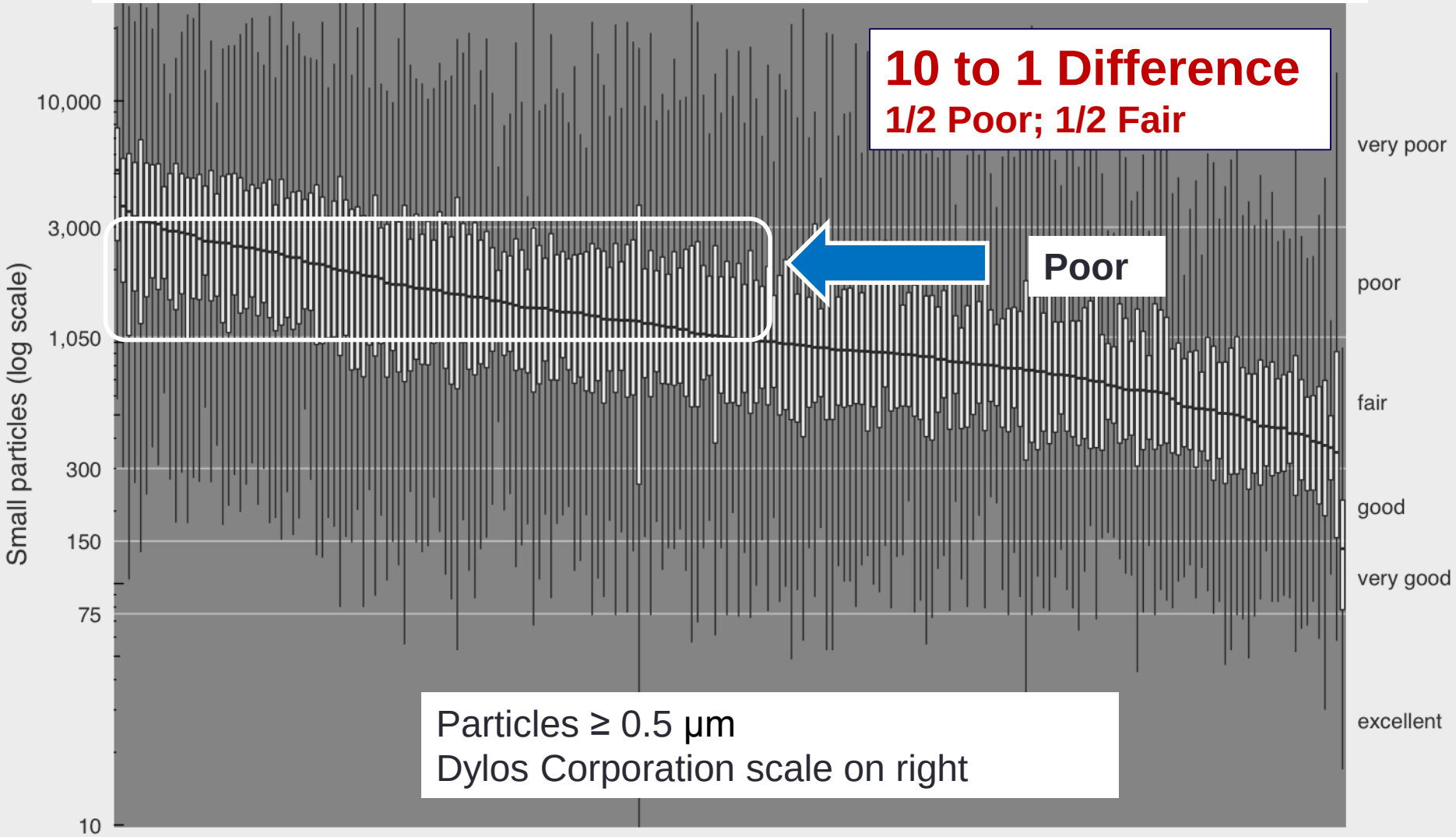

LCMP Cohorts

Participants borrow monitoring equipment to measure:

- Particles (0.5+ μm and 2.5+ μm)
- Carbon dioxide (CO_2)
- Carbon monoxide (CO)
- Radon
- Temperature
- Relative humidity

During the course of the 3+ week cohort, participants:

- Learn from the ROCIS team & each other

Participants receive weekly individualized feedback in response to their monitoring data, observations, & questions.

NEXT VIRTUAL (FREE!) COHORT

Learn more about participating

https://ROCIS.org

Monday, 7 PM, Oct. 29, 2020

Tuesday, 10:30, Oct. 30 2020

Cohort Dates

Nov. 5 - Dec. 8, 2020

Reducing Exposure

4 Strategies to Reduce Indoor Particles

- **Reduce air exchange from outside**
  - Close windows
  - Tighten home or building
- **Reduce indoor sources**
  - Use an effective ducted kitchen hood!
  - Use induction cook top & other good practices w/ cooking
- **Reduce resuspension**
  - HEPA vacuum; thoroughly clean hard surfaces
  - Walk-off mats
  - Get rid of carpets, old upholstered furniture
- **Filter the air**
  - Portable air cleaners
  - DIY Fan Filters
  - Central air handler (furnace, AC, or ventilation)

4 Options to Reduce Indoor Particles

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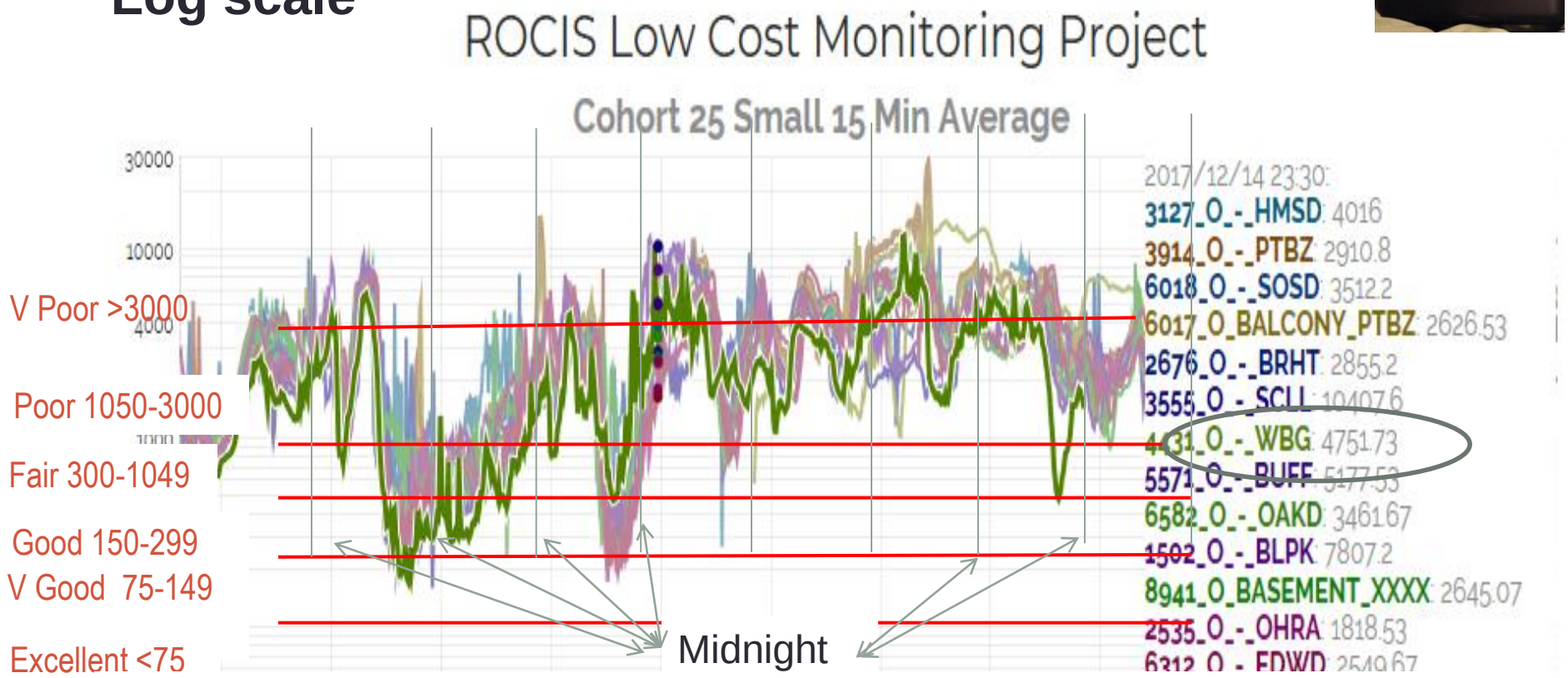
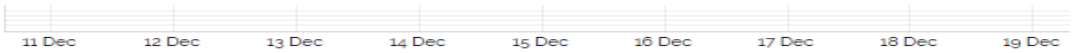
Outdoor Data by Cohort - (70 mile spread) - Readings track

Log scale

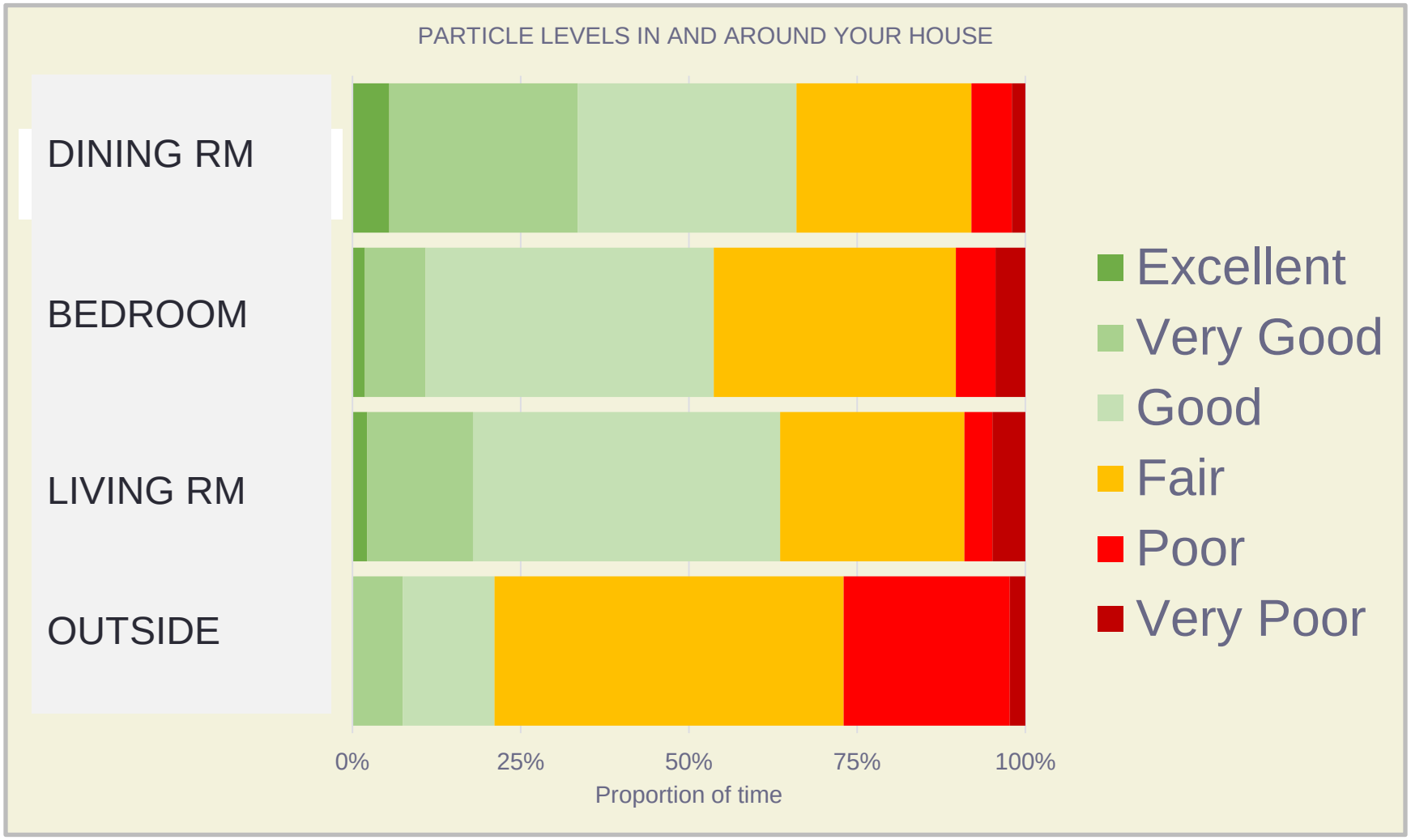


We share the same air shed!

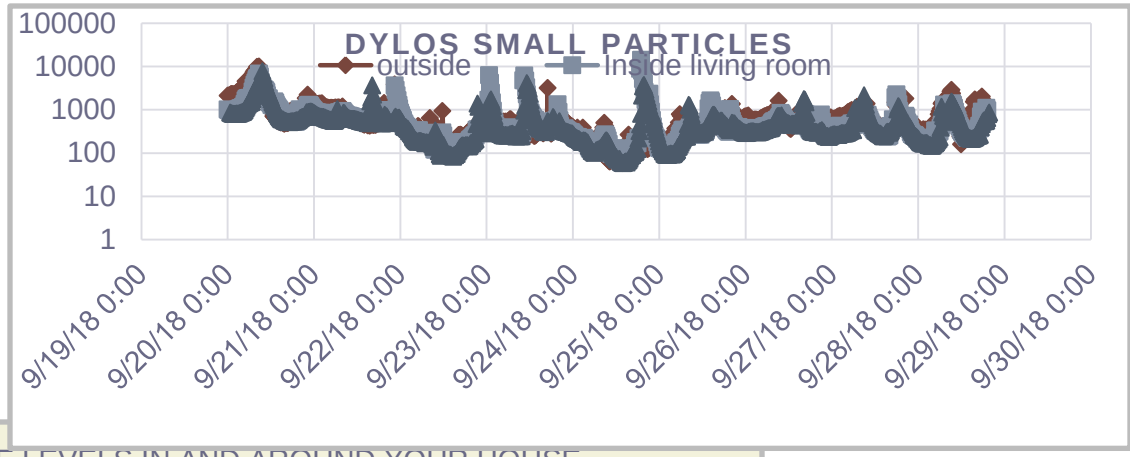
Rapid variations in outdoor particles – particularly worse at night

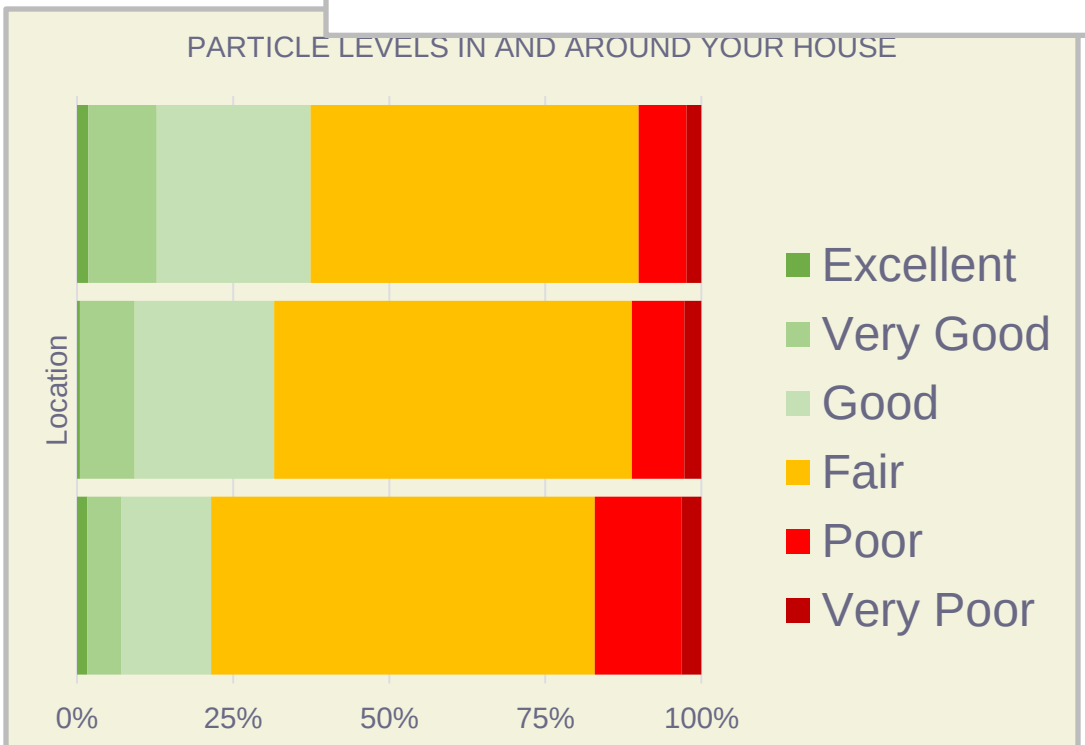


House with Windows Closed



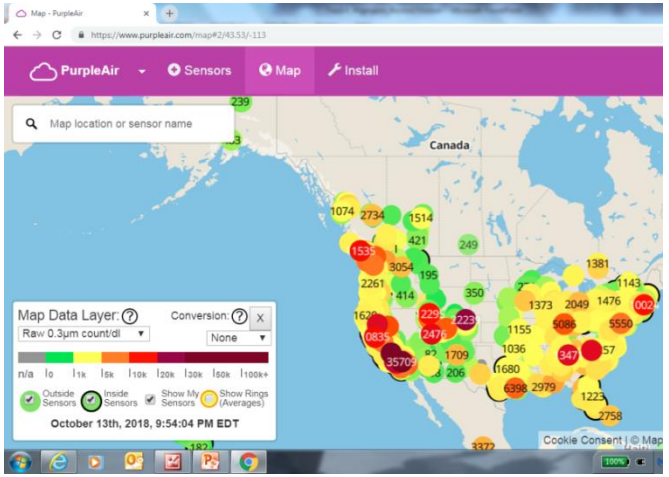
House with Wide Open Windows



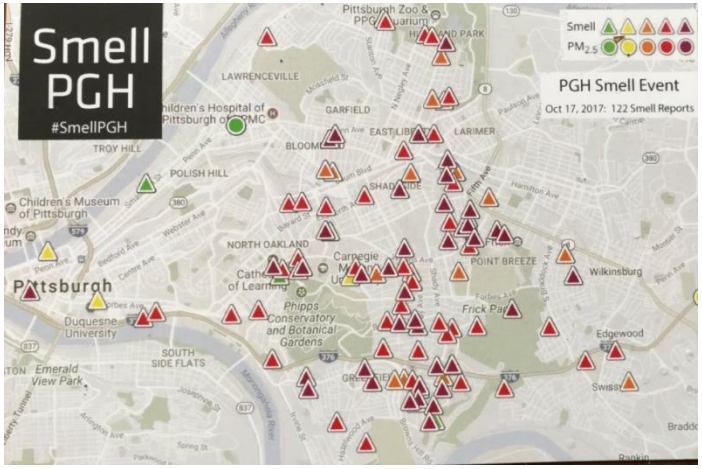


Should I Open My Windows??

- Purple Air Map - https://www.purpleair.com/map



- Smell Pittsburgh - https://smellpgh.org
- US EPA AirNow - https://www.airnow.gov/



- Create Lab VOC Monitor map - https://voc.createlab.org/?c=tVOC

4 Strategies to Reduce Indoor Particles

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  - Central air handler (furnace, AC, or ventilation)

Cooking Considerations!

Reduce emissions through

- Vented kitchen range hood
- Induction stove top unit - two burner portable option
- Cooking style (e.g. bake vs. frying bacon)
- Use lids
- Heat: Lower is better
- Cooking oil type vs. butter
- Add salt & pepper to cooking oil

Induction Cooktop or Portable Stove top

Benefits!

- ✓ Minimize gas combustion products
- ✓ Better temperature control
- ✓ Very responsive
- ✓ Lower surface temperature

Reducing Cooking Emissions

Check out ROCIS guidance document & webpage

ROCIS ISSUE BRIEF, Ducted Range Hoods: Recommendations for New and Existing Homes

http://rocis.org/kitchen-range-hoods

Online Kitchen Ventilation group:

https://www.buildingperformancecommunity.org/groups/kitchen-ventilation

Online closed group on Building Performance Community:

https://www.buildingperformancecommunity.org/groups/inexpensive-residential-particle-monitoring

Other Indoor-Generated Sources

Here's what we have seen:

Tap water in ultra-sonic humidifier (should use distilled water)

Cleaning products (avoid scented & toxic!!)

Personal care products

Recreational combustion

- Cigarettes, vaping…
- Candles, incense, diffusers

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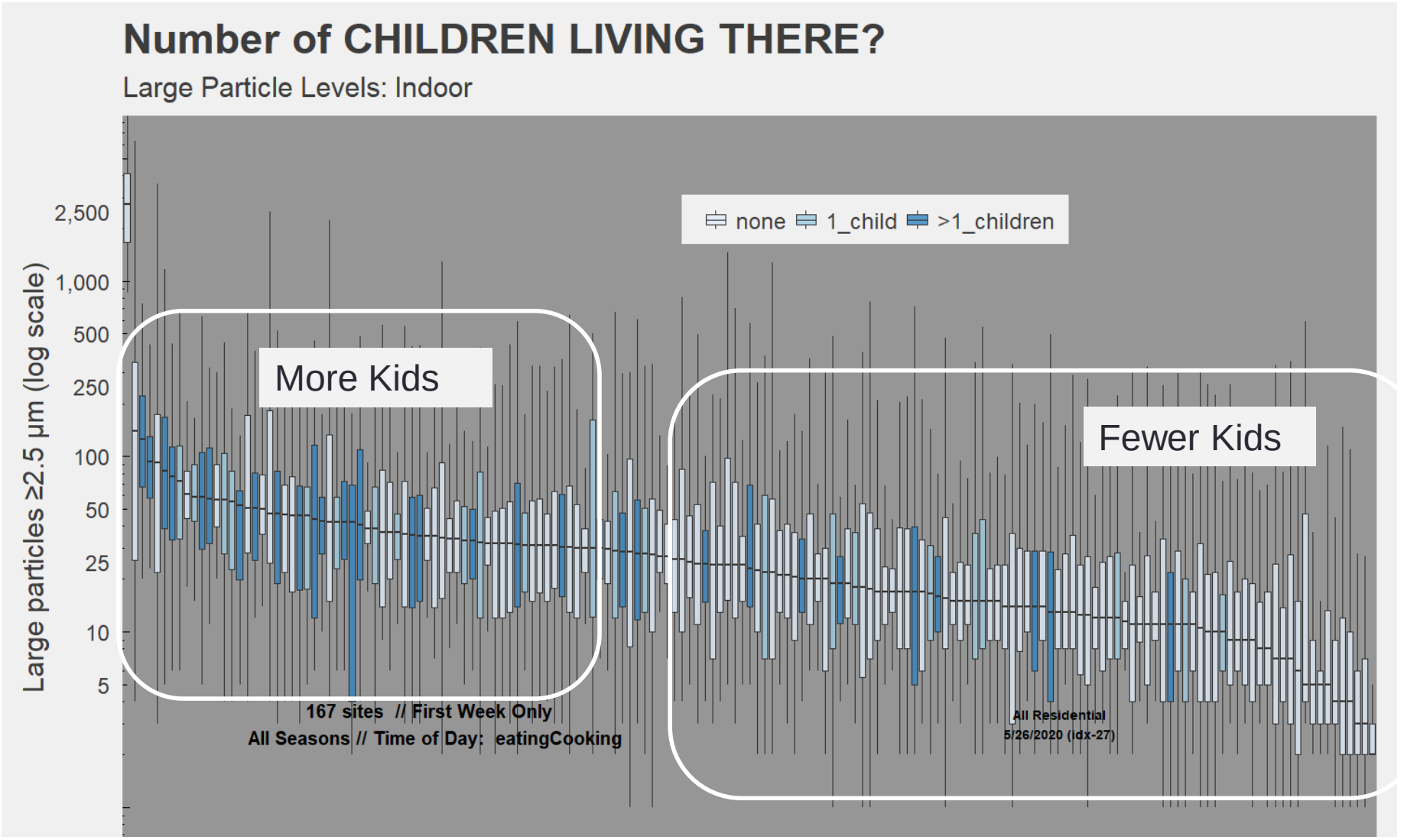
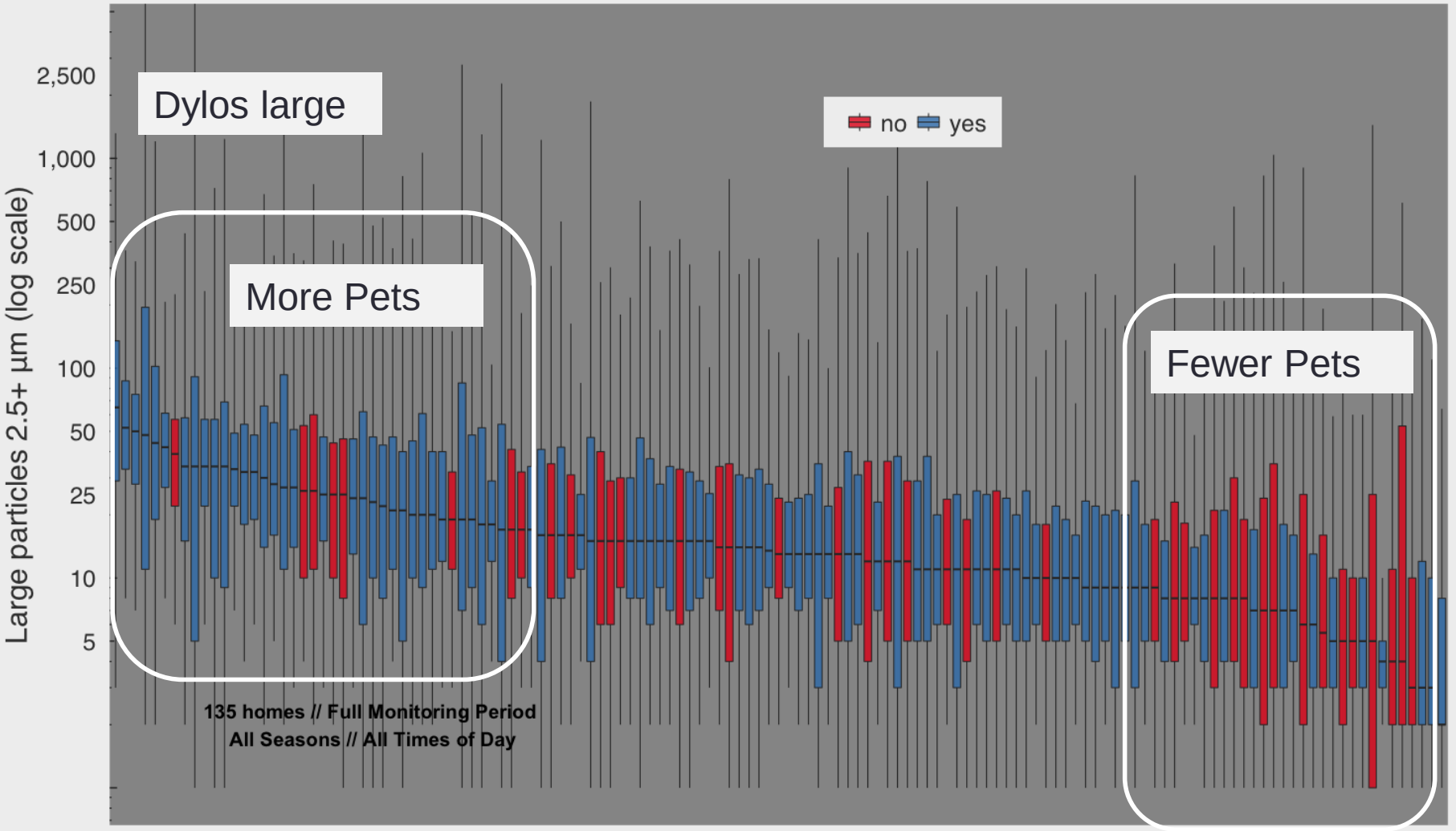
Number of CHILDREN LIVING THERE?



Do you have PETS?

Large Particle Levels: Indoor



Clean it Up or Don't Disturb it

Many particle spikes from activity are resuspended – not generated

- Carpet
- Hard surface floor
- Couch - Upholstery
- Bedding
- Laundry
- Remodeling (attics, building cavities)

What was the original source?
Emissions from 50 years ago?
Residue from remodeling?
Particles from open windows?
Tracked in lead dust?

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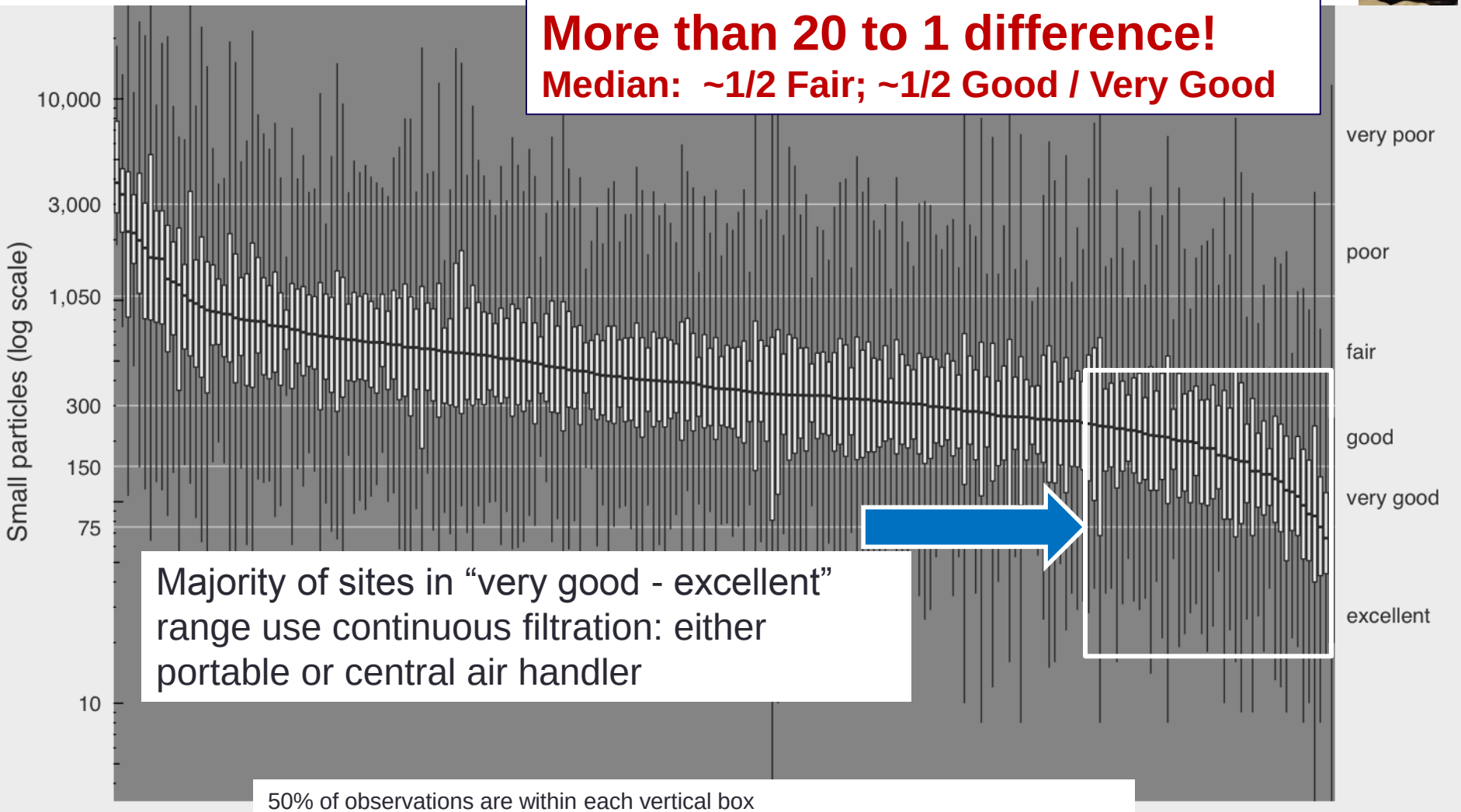
- **Filter the air**
  - Portable air cleaners
  - DIY Fan/Filter
  - MERV 13 filter in central air handler (furnace, AC, or ventilation)

Indoor Particle Distribution – All Sites

More than 20 to 1 difference!

Median: ~1/2 Fair; ~1/2 Good / Very Good



Majority of sites in “very good - excellent” range use continuous filtration: either portable or central air handler

50% of observations are within each vertical box
Particles 0.5+ µm (Dylos small)
Dylos Corporation scale (on right)

Filtration only Works When it is On!

FACTORS AFFECTING OPERATION

Maintenance

Cost of Filter Replacement

Energy Use /Energy Cost

Noise

Air Movement/Comfort –

- Comfort (summertime)
- Discomfort (wintertime)

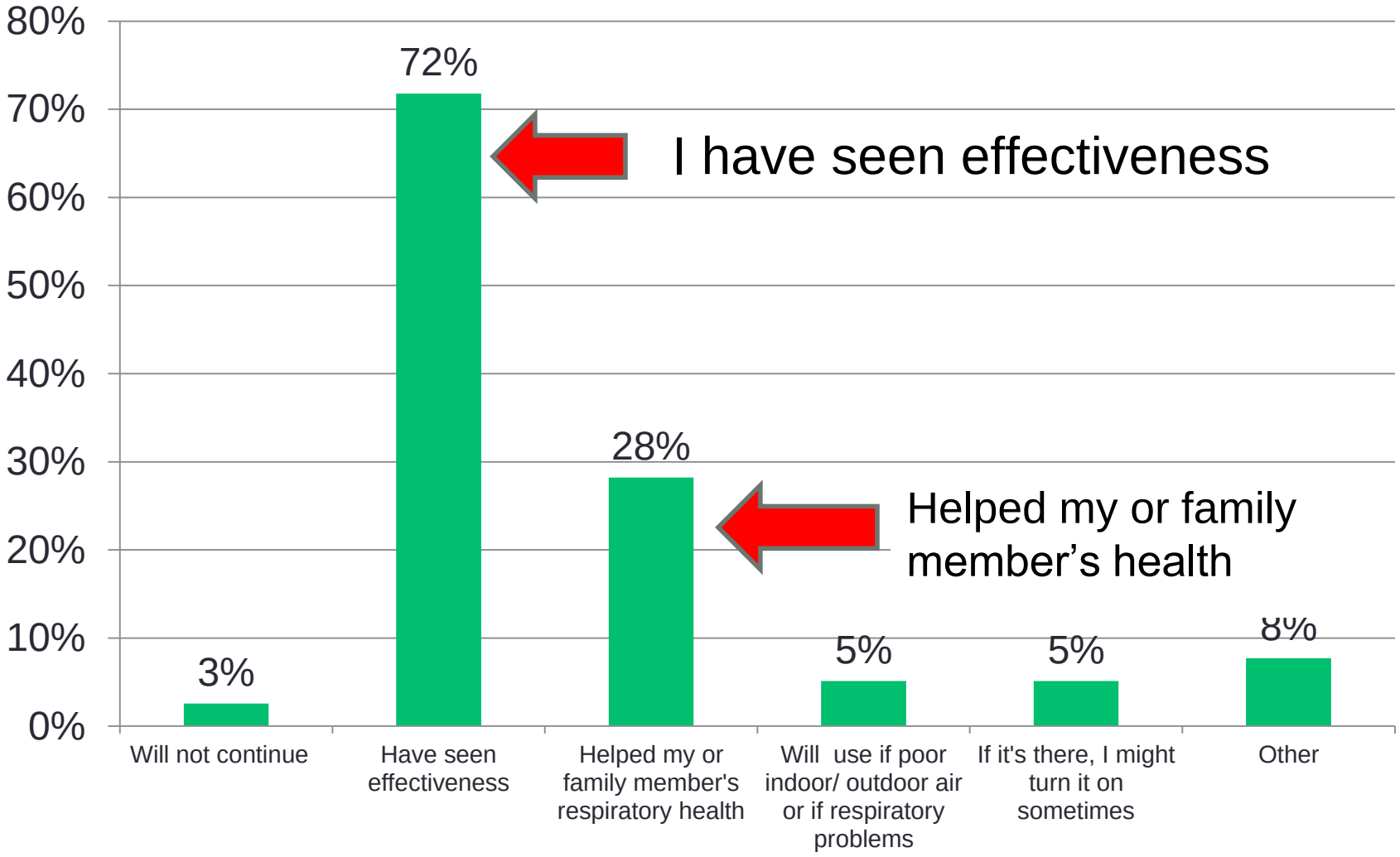
Portable Air Cleaners

Also referred to as Air Purifiers

Portable Air Cleaners (or Air Purifiers)

- Designed to treat one room or zone
- True HEPA filter for best particle reduction
- Some models offer added reduction of pollutants / odors
- Some models have a variety of features (some useful, some not)
- Properly size (ideally oversized)

Why Continue to Use an Air Cleaner or Fan/Filter?



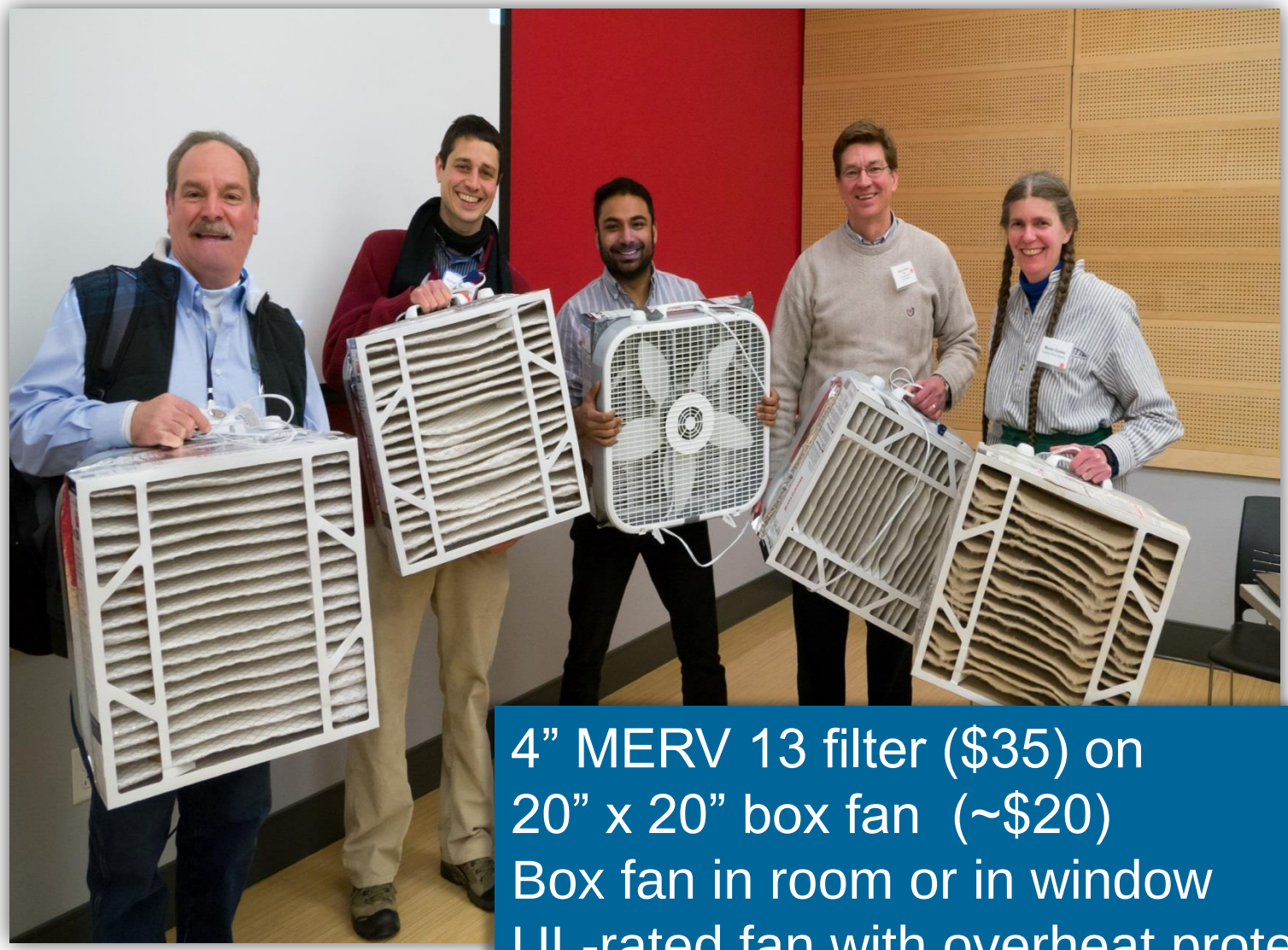
Clairton Air Filter Distribution Program

Summer 2020

- 47 households served
- Goal: treat all regularly occupied spaces
- 153 portable air cleaners (3.25/home)
- Pre & post particle monitoring (~weeks)
- Weekly contact for feedback
- $870 - Average PAC cost per home
- **Portable Air Cleaner Performance & Data here**
- http://rocis.org/clairton-air-filter-project

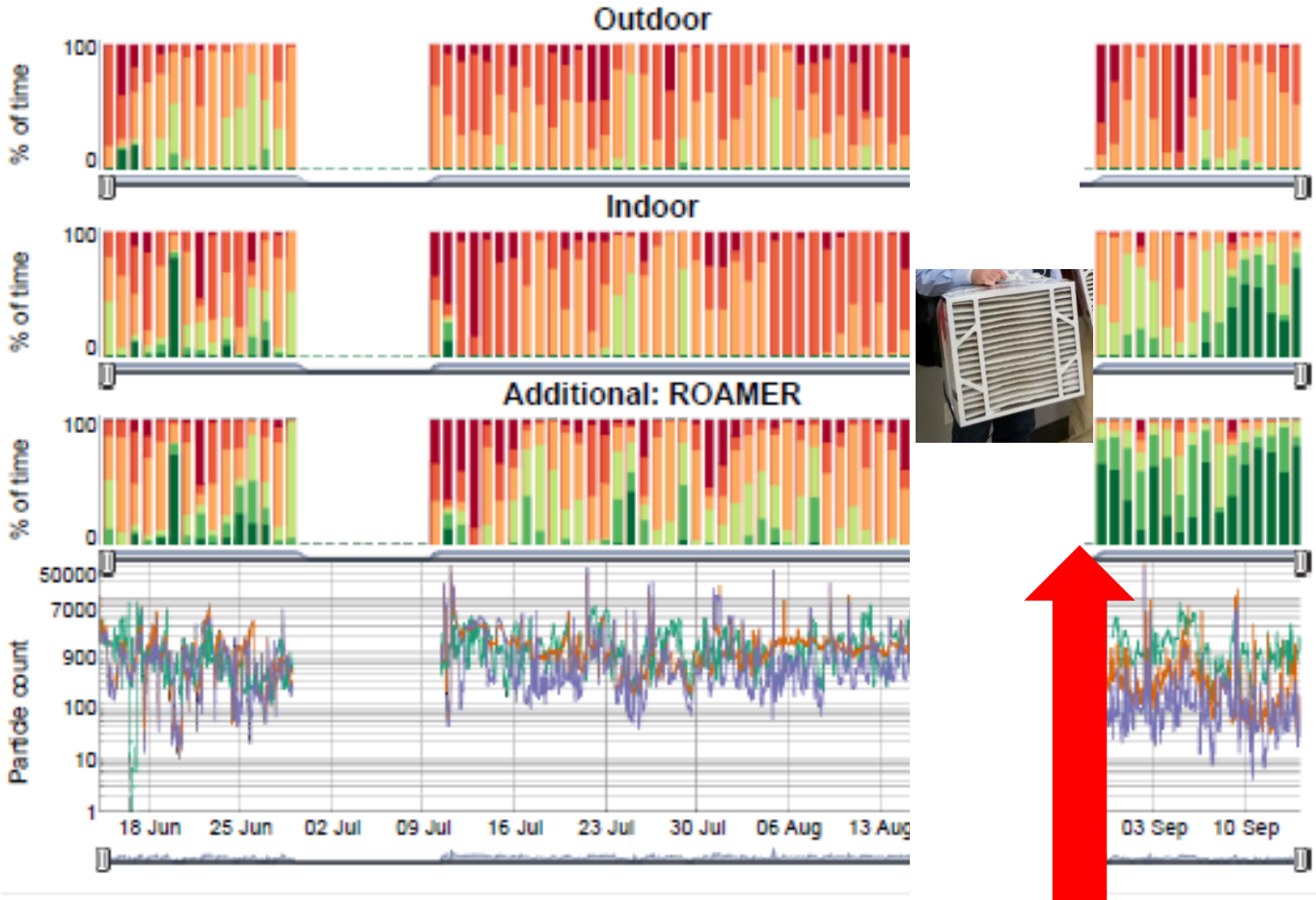
DIY Fan Filters

DIY Fan/Filter Intervention: Low Cost, MERV 13



4” MERV 13 filter ($35) on
20” x 20” box fan (~$20)
Box fan in room or in window
UL-rated fan with overheat protection

Indoor Fan/Filter 24/7 Impact

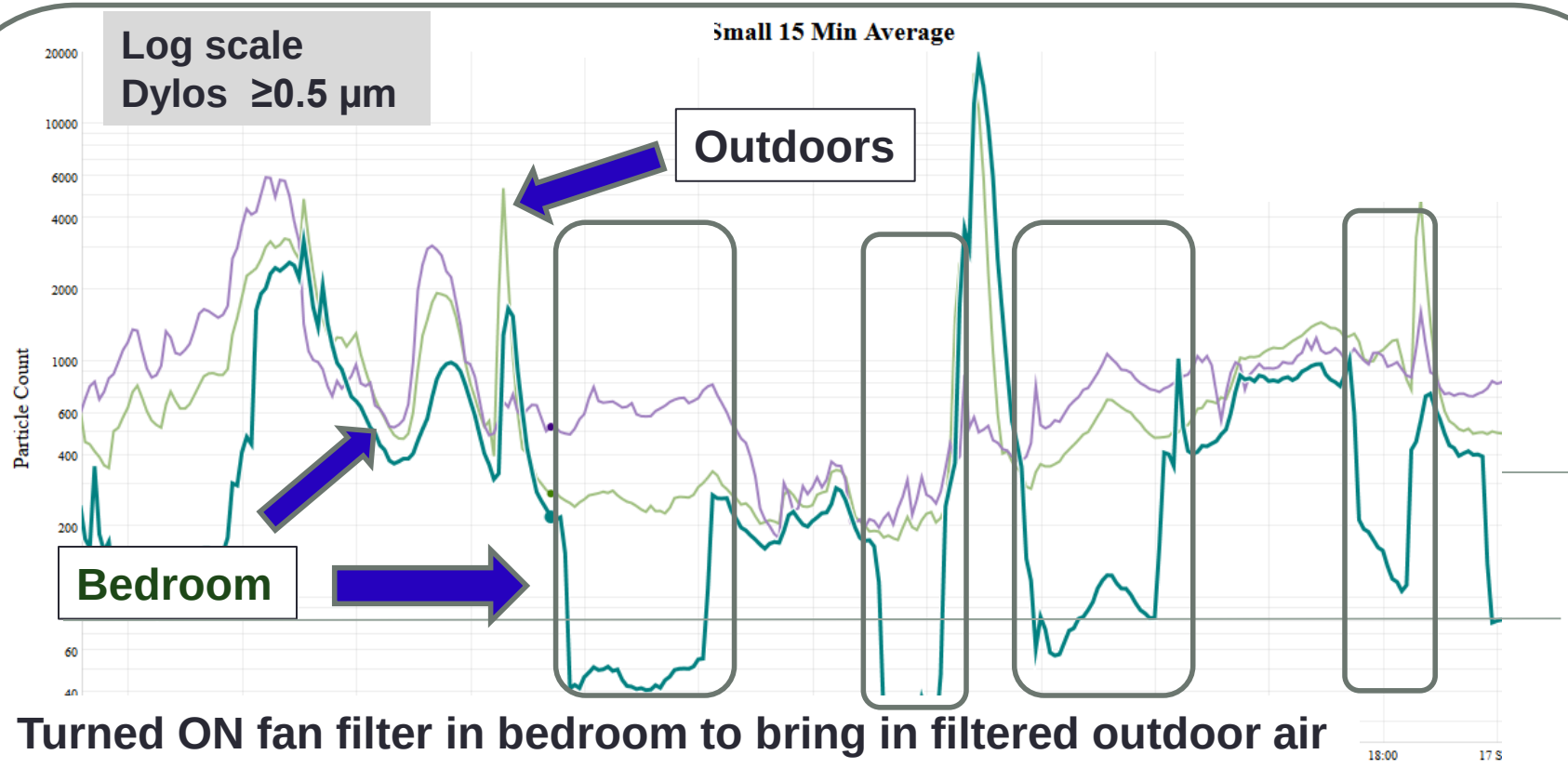


http://rocis.org/rocis-data-explorer (k4x3)

Fan/Filter Intervention– Bedroom Window at Night

Open window with/without box fan & filter on:

Indoor tracks outdoor closely



Turned ON fan filter in bedroom to bring in filtered outdoor air
Turned OFF fan filter each morning (f5q4)

Fan/Filter Options
20” Box Fan w High MERV Filters

- **Some use multiple filters (2 in V, or 4 in box)**

https://www.treehugger.com/build-own-covid-19-air-filter-5081272?

Image Credit: Comparetto Comfort Solutions

Air Handler/high MERV Inquiry

High MERV Filter - Air Handler (Filter/AHU) Inquiry

Initial Question…

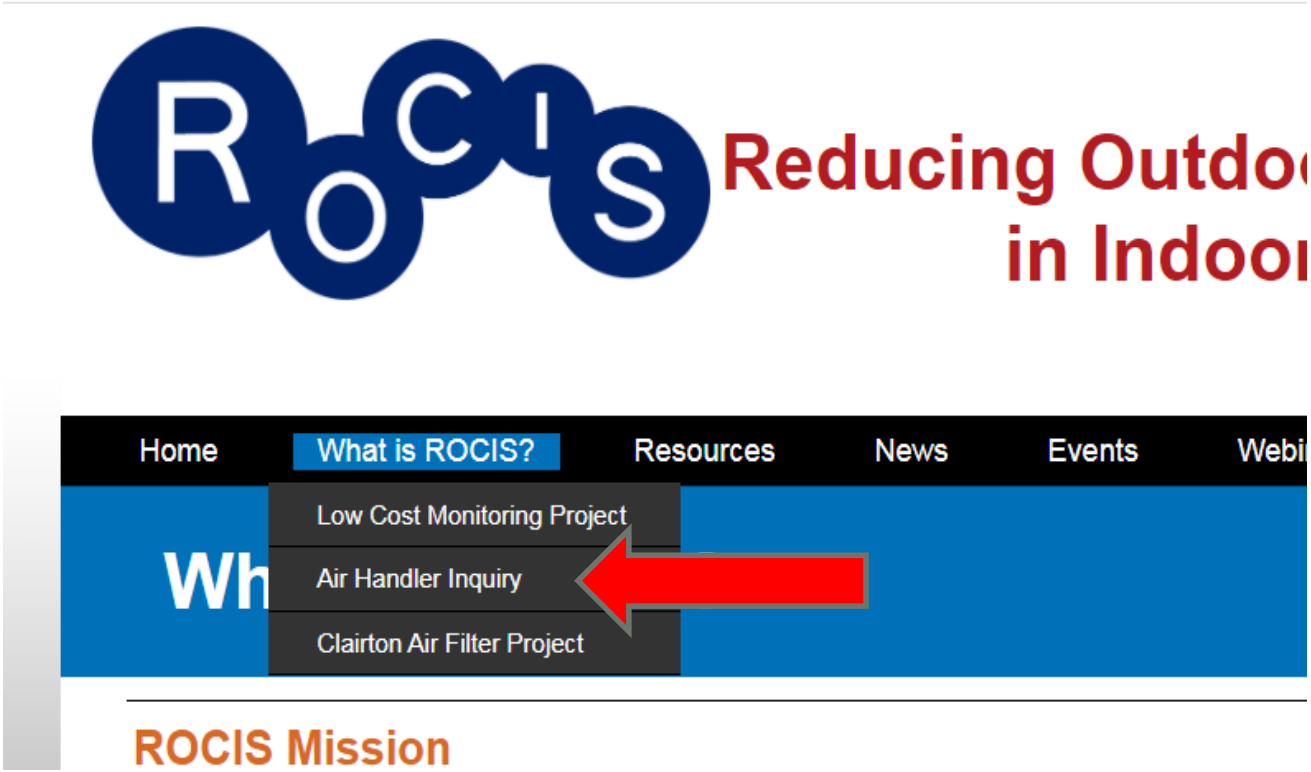
Is there an **easy way** to determine if I can use a high MERV filter with a **longer air handler run-time** without causing problems ($, equipment durability, performance, or GHG emissions)?

NO !!

Diagnostic Screen is Required

ROCIS 24/7 Air Handler Checklist

http://rocis.org/air-handler-inquiry



Big Issues with 24/7 High MERV Filter

Air handler (AHU) energy use & cost can be high due to 500 to 1,500 watt-draw

- High cost of running air handler continuously (360 kWh to 1080 kWh/month = ~$500 to $1500/year[1])

Wrong blower speed

- Seldom set in field
- Often defaults to high speed, not low, in continuous mode
- Higher energy cost, less effective filtration

Ductwork issues introduce additional problems

- Static pressure too high (can lead to equipment failure)
- Duct leaks (energy waste & pressure-related problems)

[1] **$0.12/kWh**

Pre

16x25x1 MERV 12

Post

20x25x4 MERV 13

Labor & material cost: ~$1,000
24/7 monthly operating cost: ~$12.50

CASE STUDY: Indoor Air Quality Interventions
Chris Guignon, evolveEA

Big Opportunity at HVAC Replacement

- ***Downsize HVAC to reduce static pressure!!***
- Incorporate return drop modification & option for larger, deeper filter
- Set blower speeds for optimal performance
- Address duct system shortcomings

- To ponder…
  - Could potential filtration health & comfort benefits add impetus to getting HVAC systems designed & installed correctly?

FILTRATION RESOURCES

- EPA Guidelines - Air Cleaners & Air Filters in the Home
  https://www.epa.gov/indoor-air-quality-iaq/air-cleaners-and-air-filters-home-0
- ROCIS website - http://rocis.org/air-handler-inquiry
  http://rocis.org/clairton-air-filter-project

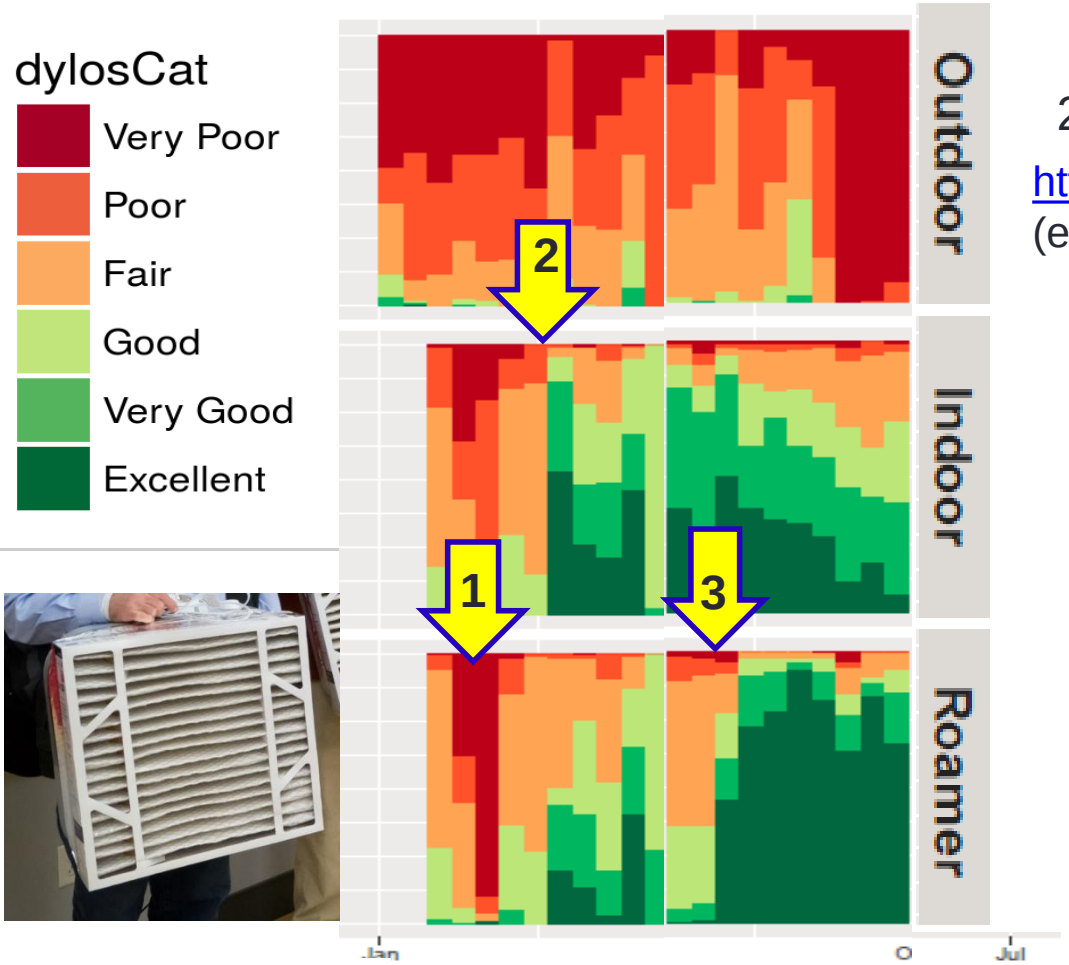
Digging Deeper

- IL Institute of Technology (Built Environment Research Group) (papers & presentations) http://built-envi.com/
- IAQ Scientific Findings Resource Data Bank
  https://iaqscience.lbl.gov/indoor-air-quality-iaq-scientific-findings
- ASHRAE Epidemic Task Force
  https://www.ashrae.org/about/news/2020/ashrae-introduces-updated-reopening-guide-for-schools-and-universities
- **NAS HVAC Strategies for COVID-19 Webinar**
- 2 - 3:30 PM (EDT), Wed. Oct. 28, 2020 Register here

SUMMARY

Behavior *Plus* Technical Intervention

Motivated Occupant



Fan/Filter

By 1-week periods

2-burner Induction Stovetop

http://rocis.org/rocis-data-explorer (h9j2) (example 2)

INTERVENTIONS

1) **Change use of humidifier**
2) **Add induction stovetop & use fan/filter (living room)**
3) **Add fan/filter (bedroom)**

Social Justice Concerns

Increased indoor particles are associated with

- Older homes
- Attached dwellings
- Substandard housing stock
- No air conditioning
- Higher occupancy
- Cooking (ethnic or cultural traditions – higher emissions)
- Unvented kitchen stoves
- Proximity to traffic & other point emission sources

4 Conclusions

1. **Low cost monitors - reinforce behavior & investment**
2. **Less outdoor particle pollution - much less indoor levels**
3. **Occupants & building systems - significant impact on particle levels**
4. ***Better outdoor air quality & housing stock/building systems - critical to reduce disparities & to improve health***

Bottom Line!

Integrated solutions are needed to enhance health, resilience, energy efficiency, comfort, & durability (engagement, building tightness, source control, O&M)

Improve outdoor air quality!

Develop champions!

The most effective low cost monitor is a motivated, knowledgeable occupant!

Thanks to The Heinz Endowments for support of the ROCIS initiative (Reducing Outdoor Contaminants in Indoor Spaces)

And 350+ LCMP participants

Questions & Comments Welcome!

This presentation:

http://rocis.org/past-rocis-events

Upcoming Cohort - sign up **http://ROCIS.org/**

Access to resources & research results

- LCMP http://rocis.org/rocis-low-cost-monitoring-project
- ROCIS Brief - Ducted Range Hood (Tom Phillips)
  - http://rocis.org/kitchen-range-hoods
- Air Handler Inquiry http://rocis.org/air-handler-inquiry
- ROCIS Data http://rocis.org/rocis-data
- Clairton Air Filter Project
  - http://rocis.org/clairton-air-filter-project

- Stay Tuned
  - Video Shorts - Telling the Story

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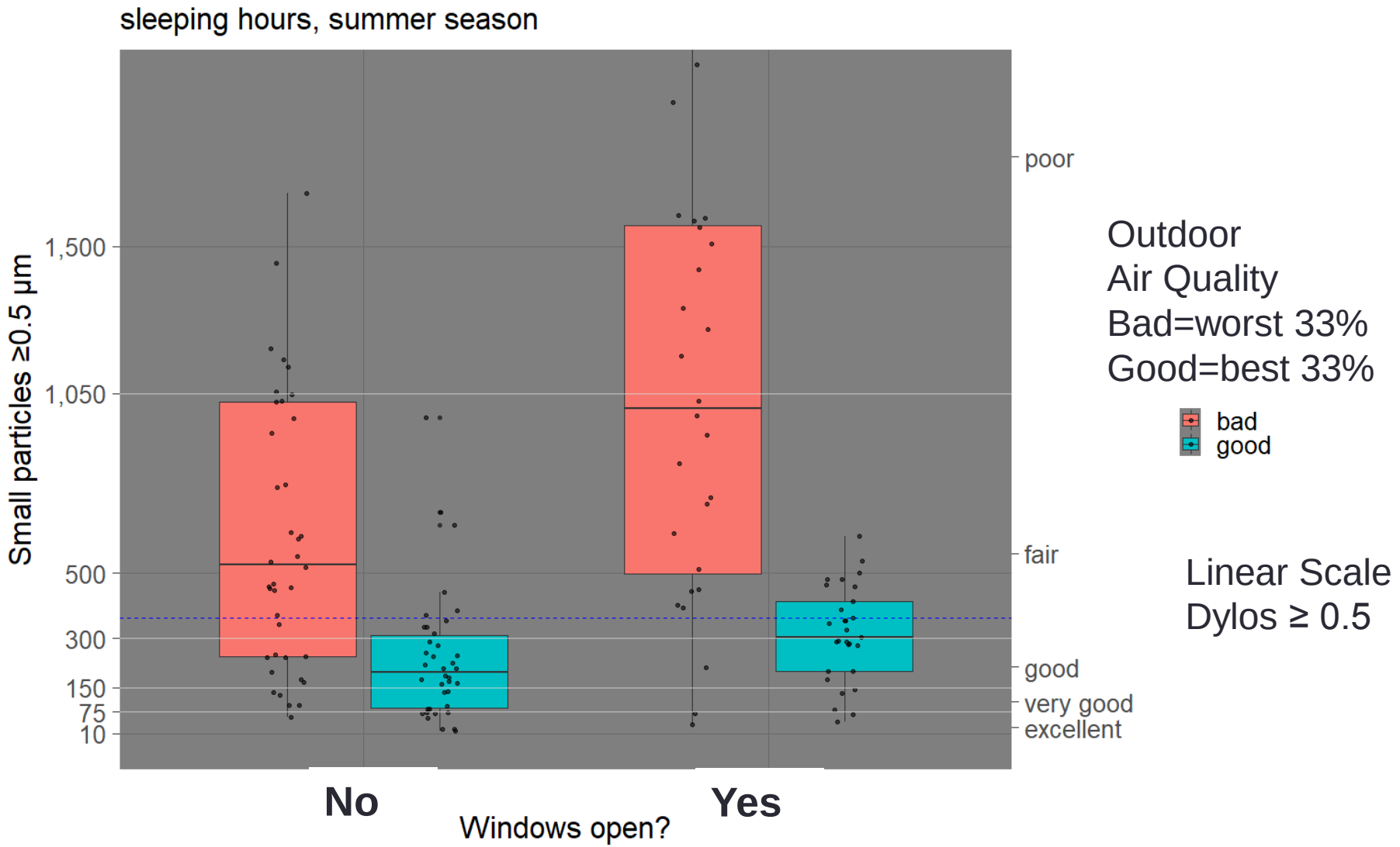
http://ROCIS.org/

INSIGHTS FROM ROCIS MONITORING DATA

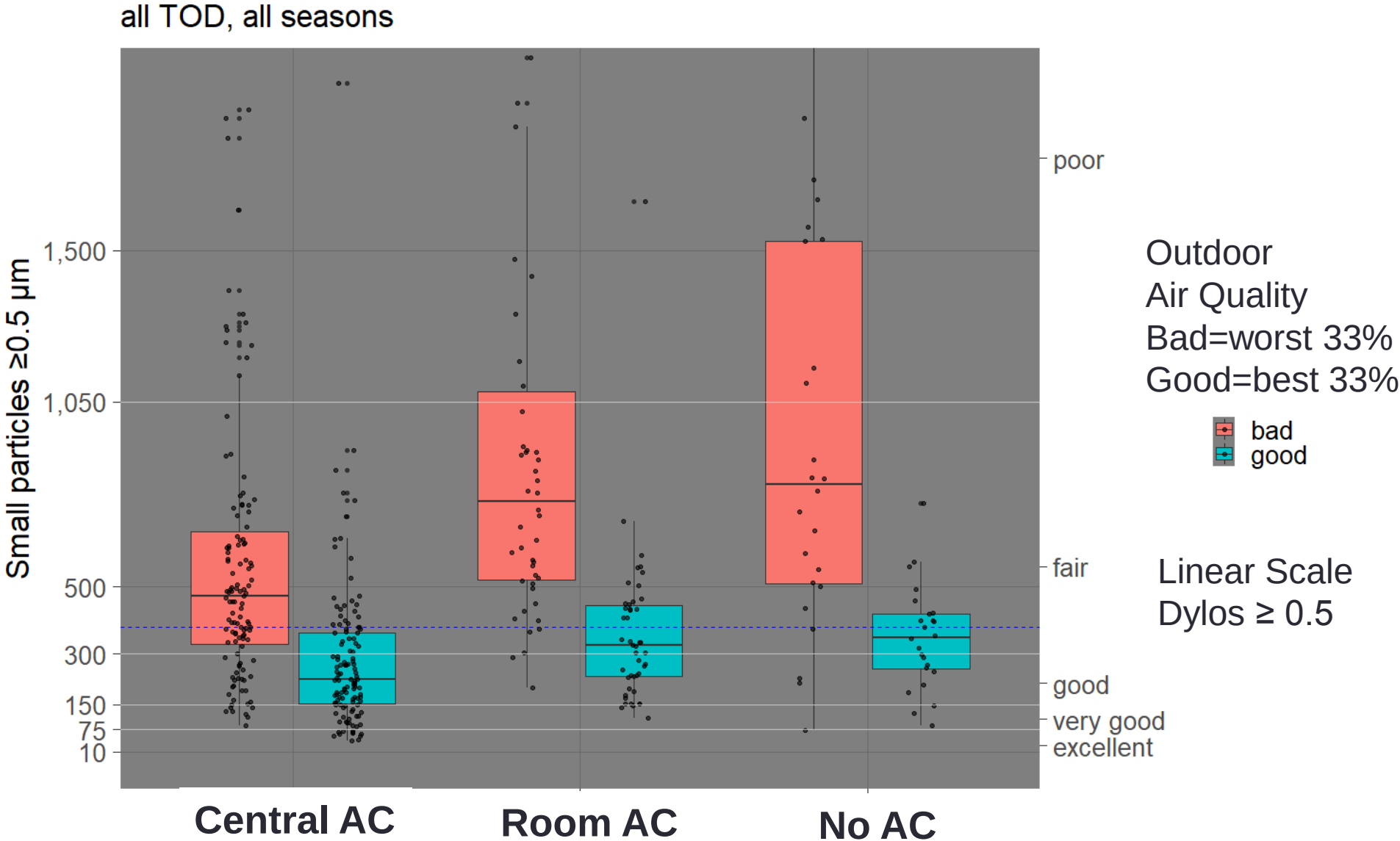
Indoor Particle Levels

Tendency to Open Windows Compared to Outdoor Particle AQ



Indoor Particle Levels

Air Conditioning Type by Outdoor Particle AQ

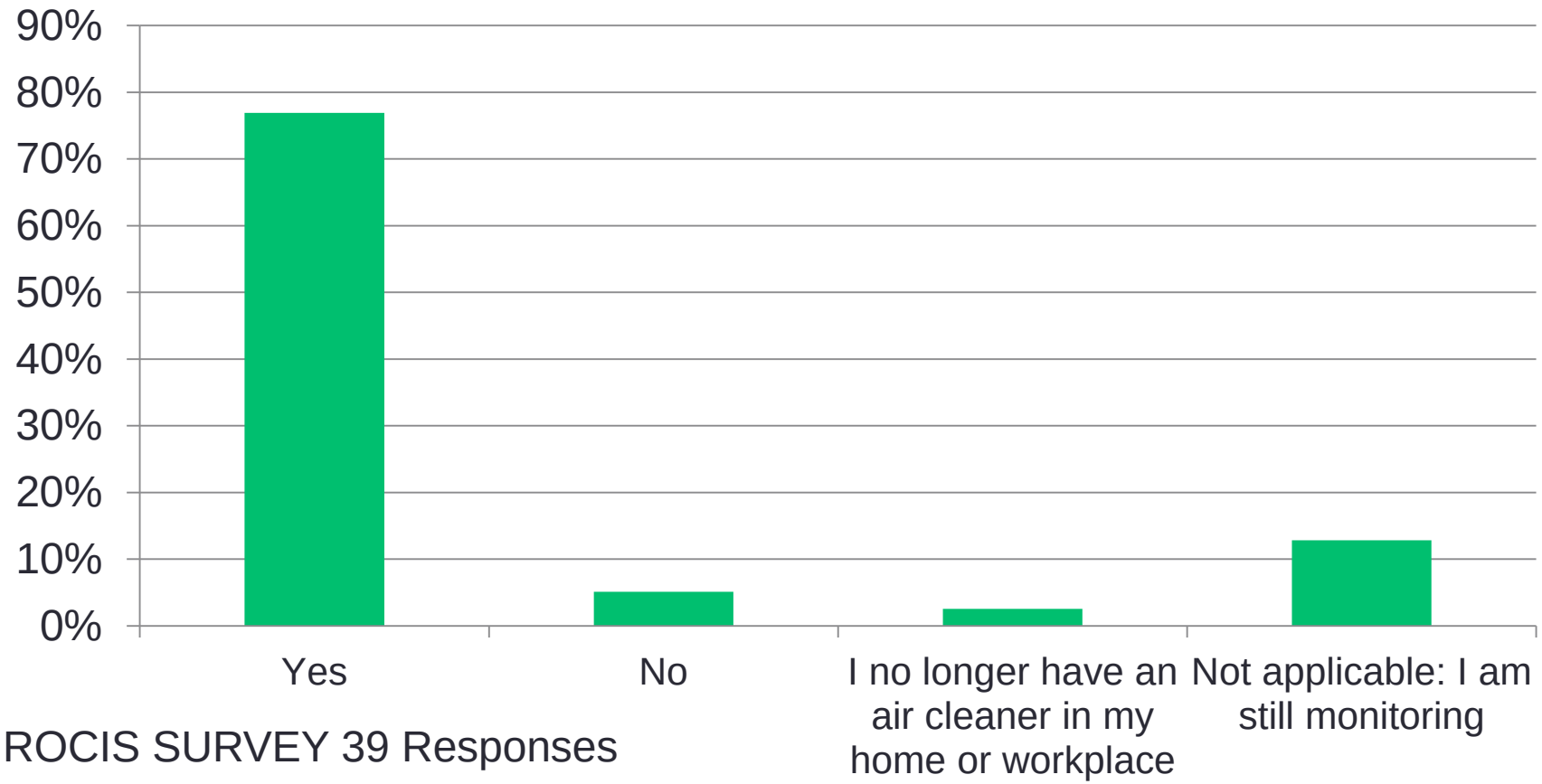


INSIGHTS / RESULTS FROM ROCIS INTERVENTIONS

Portable Air Cleaners

Also referred to as Air Purifiers

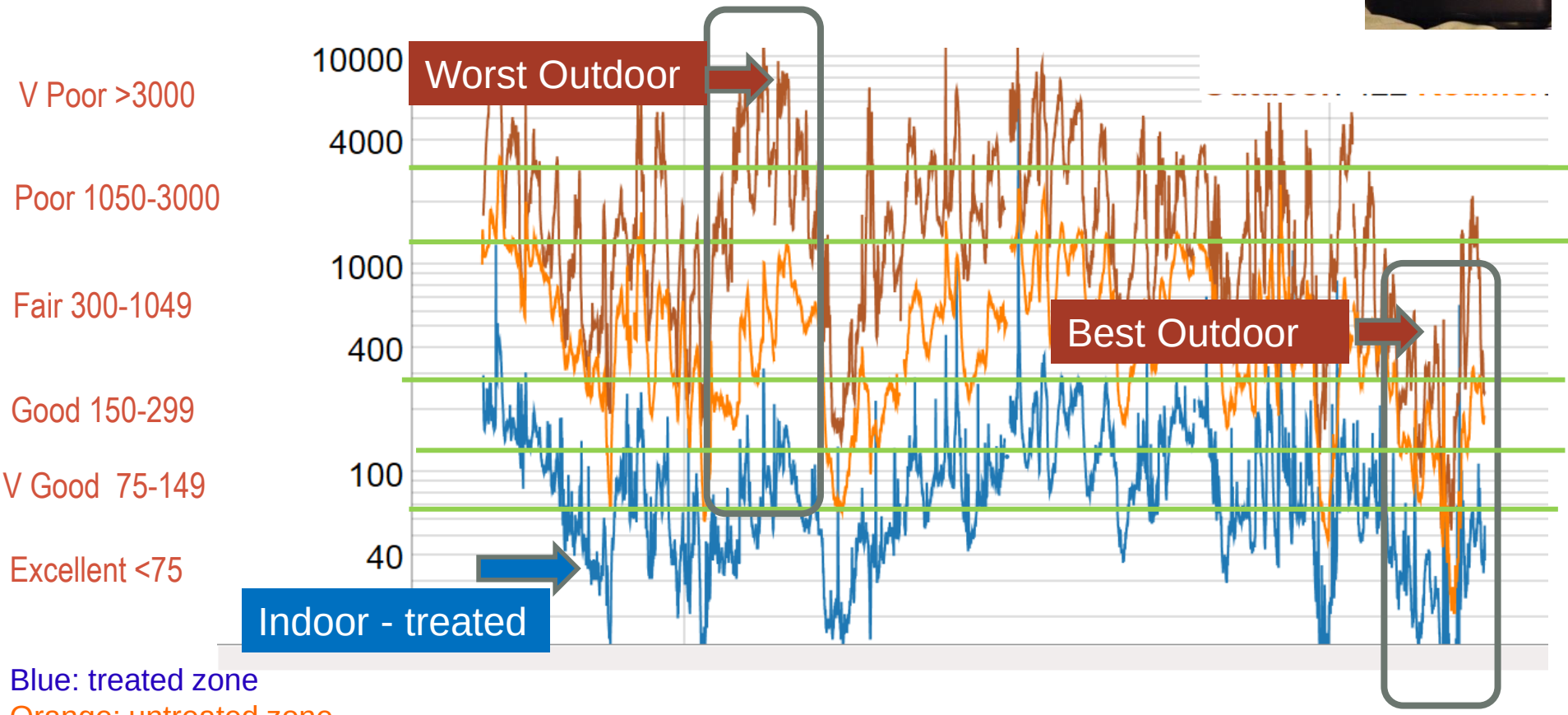
Did You Continue Using Your Air Cleaner or Fan/filter After ROCIS Monitoring?



ROCIS SURVEY 39 Responses

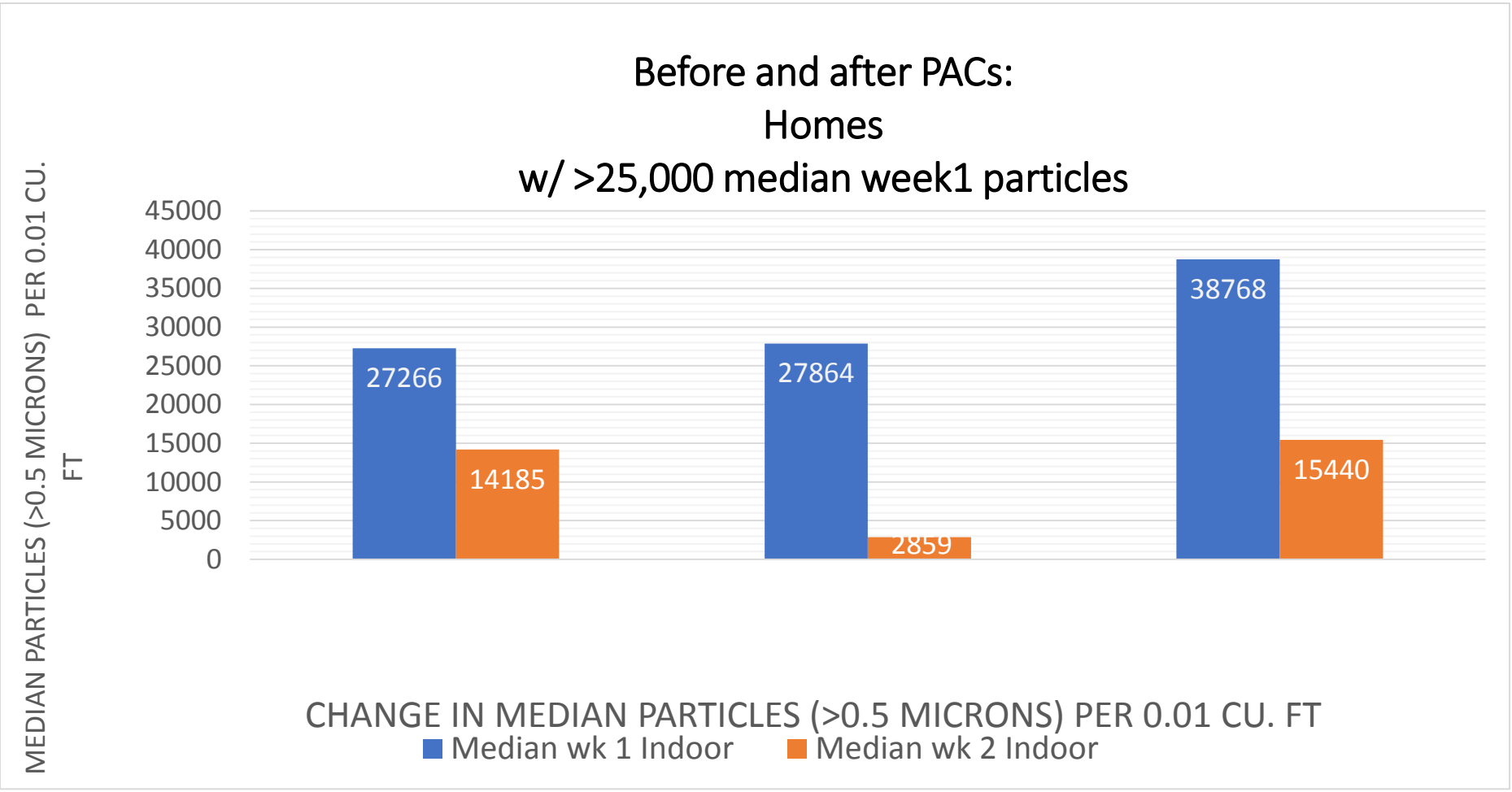
Online Data Explorer
Indoor Counts Track Outdoors

http://rocis.org/rocis-data-explorer (j1t8) ≥ 0.5µm Particles by Time (15-min. avg.)

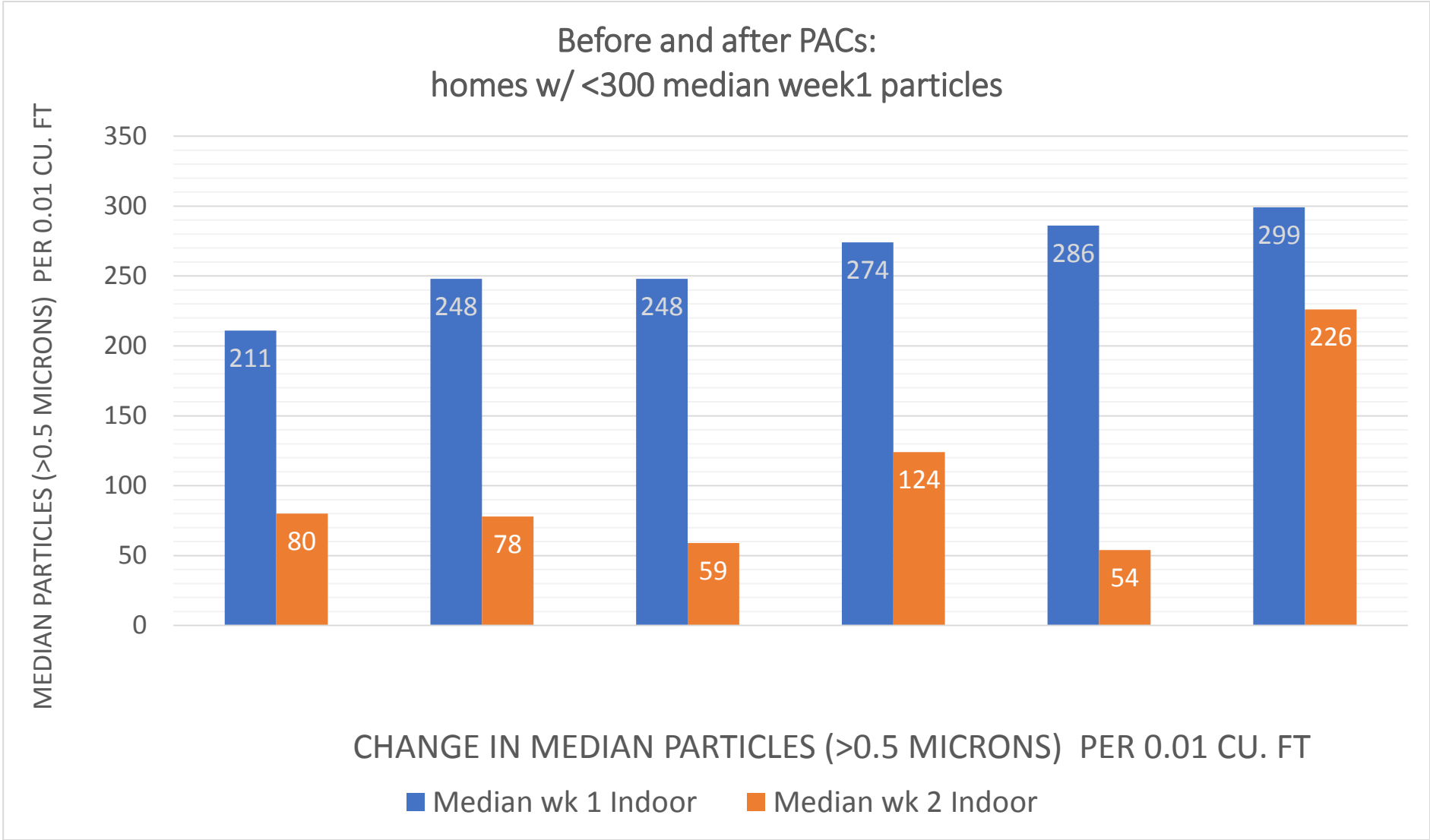


Blue: treated zone
Orange: untreated zone
Deep red: outdoors
Tight, single family home
Though order of magnitude lower; Indoor (Blue/orange) tracks Outdoor

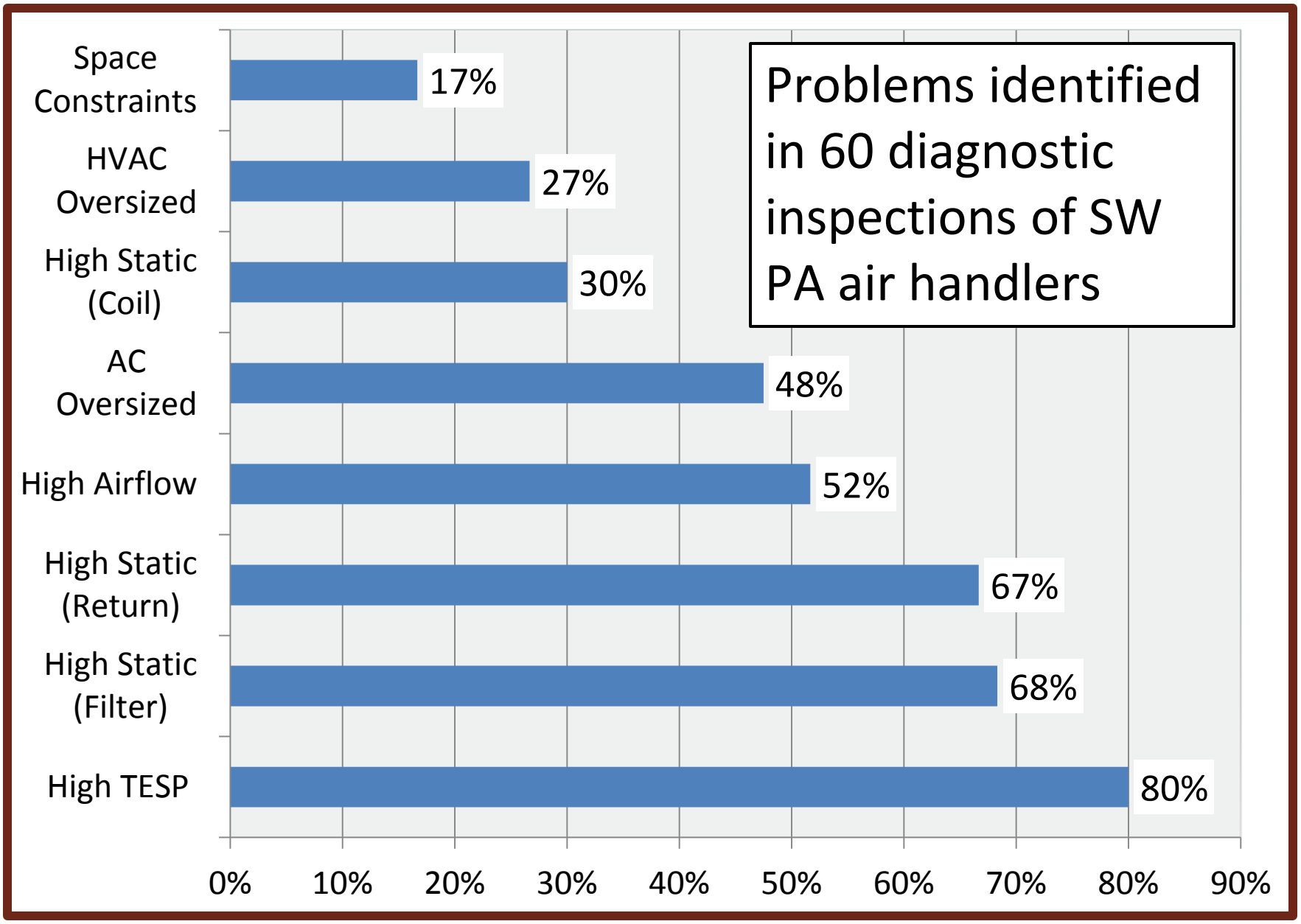
Clairton Air Filter Project
Reductions – Very High Pre-Particles



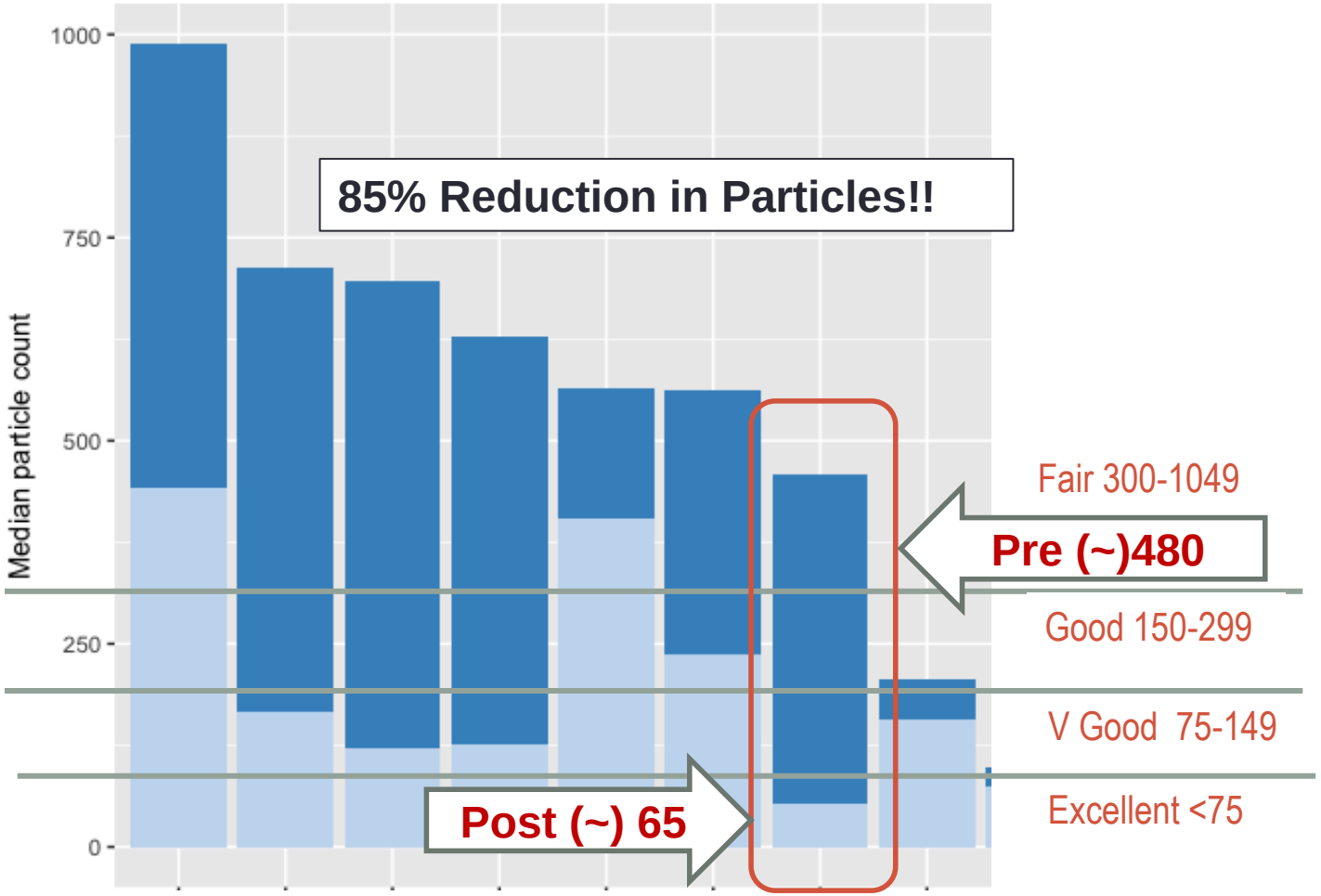
Clairton Air Filter Project
Reductions: Low Pre-Particle Count



Air Handler/high MERV Inquiry

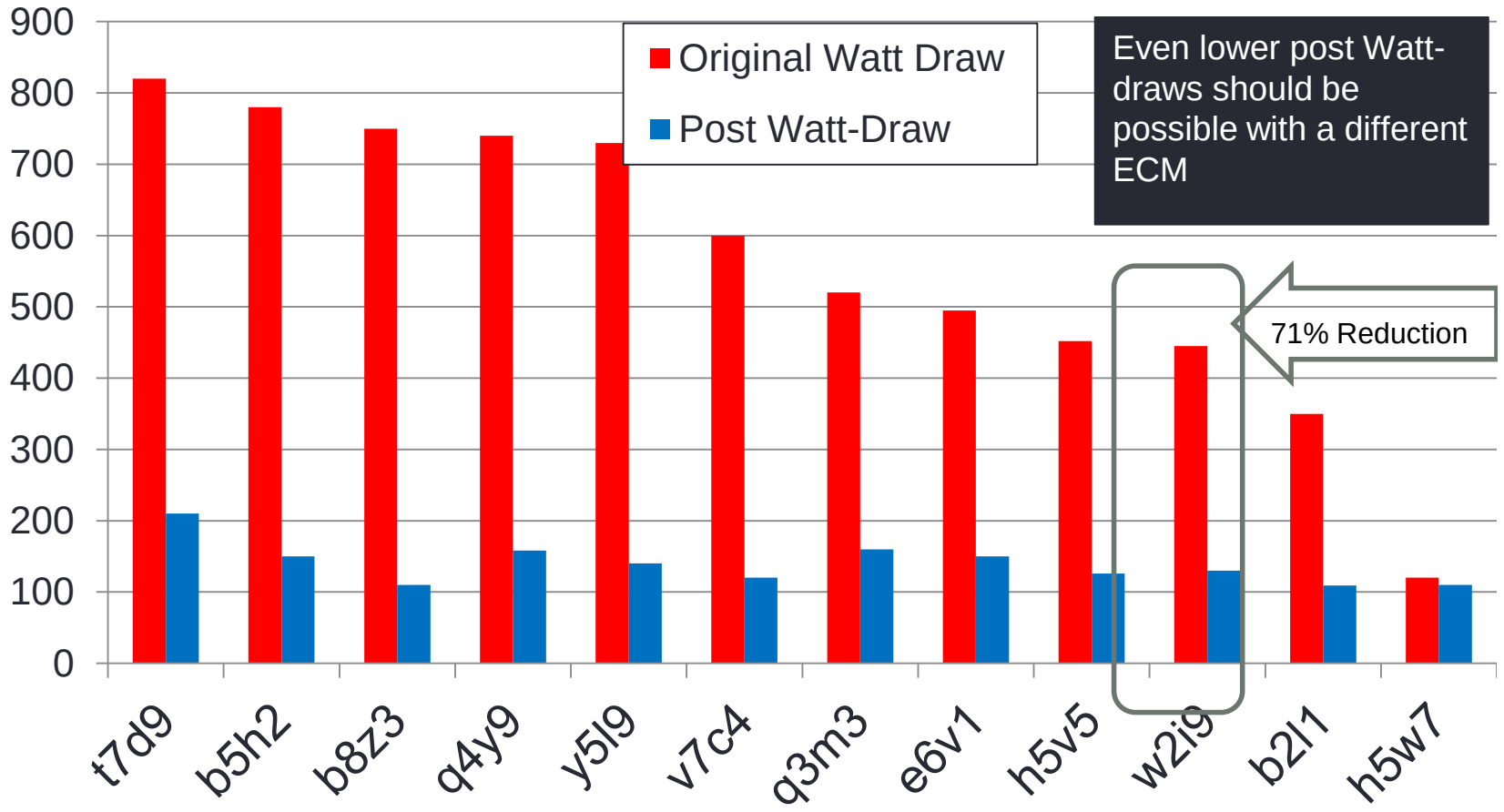

Problems identified in 60 diagnostic inspections of SW PA air handlers
Space Constraints
17%
HVAC Oversized
27%
High Static (Coil)
30%
AC Oversized
48%
High Airflow
52%
High Static (Return)
67%
High Static (Filter)
68%
High TESP
80%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%

Selected ROCIS Intervention Homes Pre-Post Median Particle Count



Use above code **(w2i9)** to view data on ROCIS LMCP Data Explorer
http://rocis.org/rocis-data-explorer

Air Handler Interventions
Pre-Post Continuous Watt-Draw



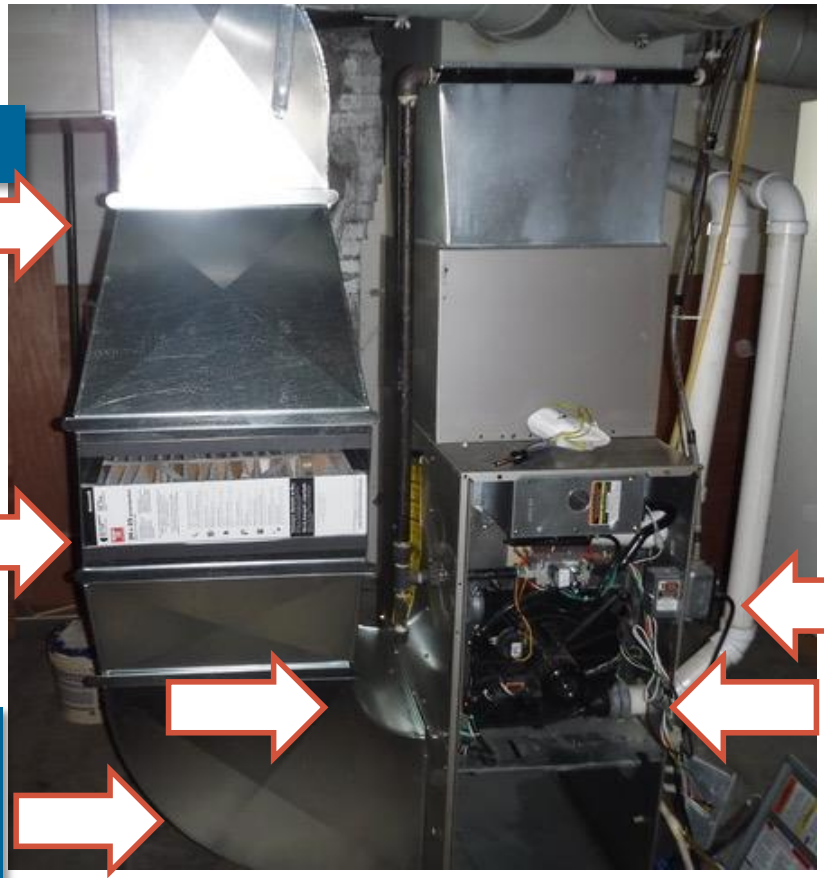
Use these codes **(w2i9)** to view particle data on ROCIS LMCP Data Explorer
http://rocis.org/rocis-data-explorer

Case 2: Air Handler Retrofit 2.0

Larger return drop

2-part filter rack (20” x 25”) Horizontal (4” MERV 13 + 2” pre or post filter)

90 degree transition designed for better air flow (heel & throat); lower static



ECM replacement

Fan speed adjusted to optimize heating, cooling, & continuous performance.

RESULTS:

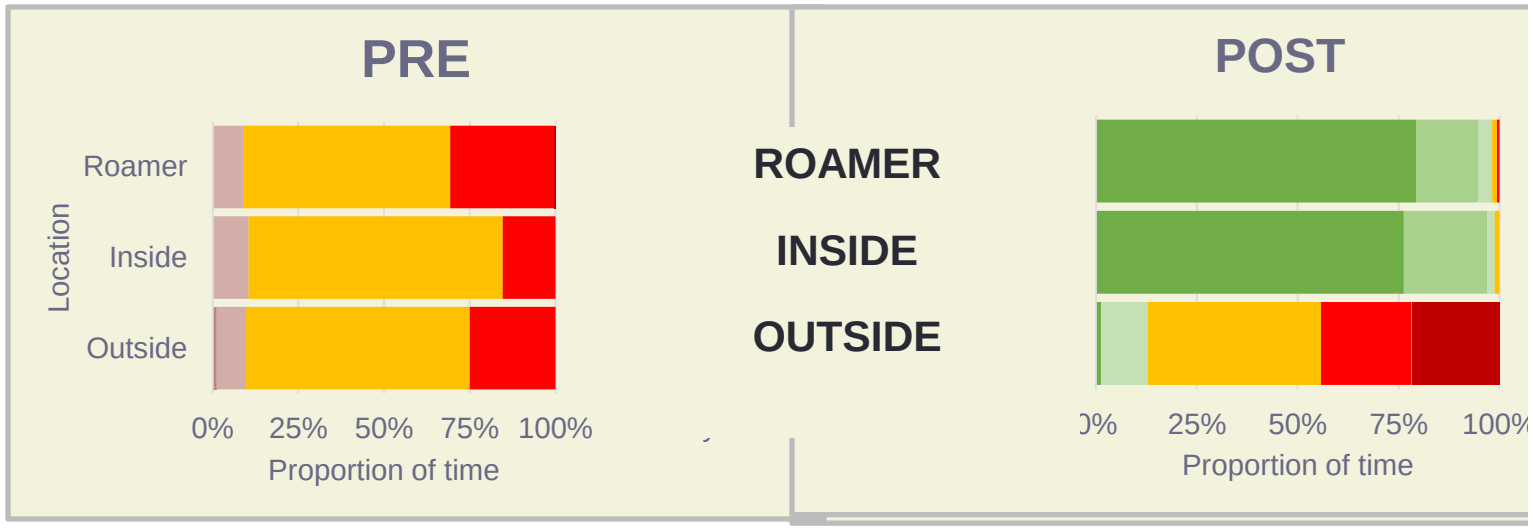
In continuous mode:

- 4.27 CFM/watt
- 120 Watts

- Pressure drop across filter Pre: 93 Pa, Post: 16 Pa
- **Allowable TESP: 125 Pa**
- **(total system)**

Case 2 Pre & Post Particles

Air Handler Retrofit

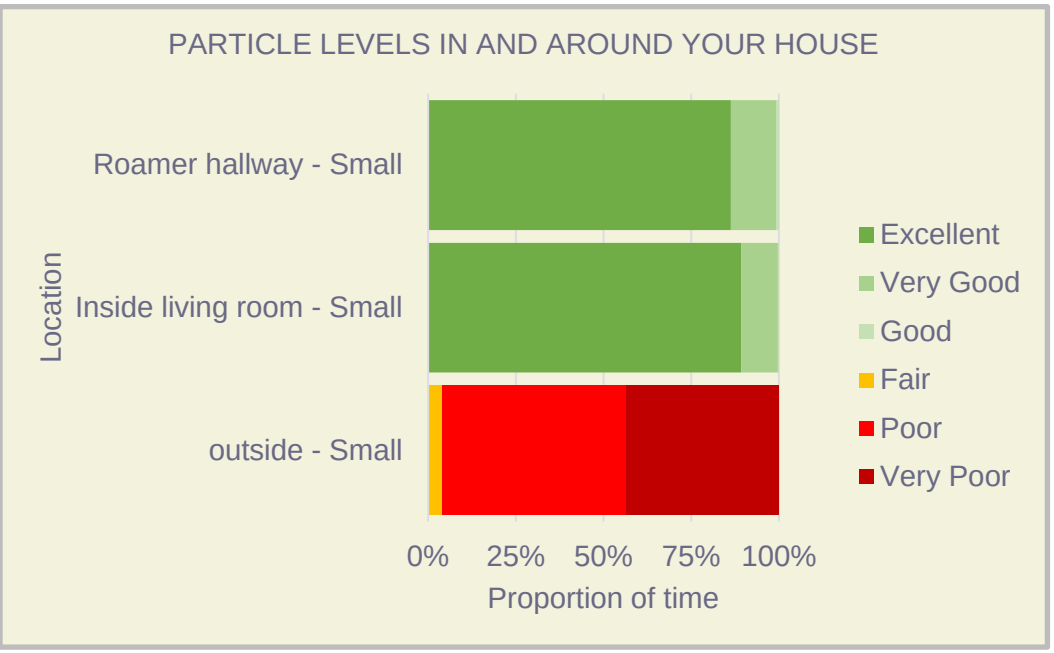


Week ending 5-24-2017 **(windows open)** vs. 7-31-2017, poorer outdoor counts

INTERVENTION:

ECM blower (lower air flow & energy cost on continuous setting)
New return (larger 20” x 25” MERV 13 filter & pre-filter)

Labor & material cost: $1,000
24/7 monthly operating cost: ~$12.50

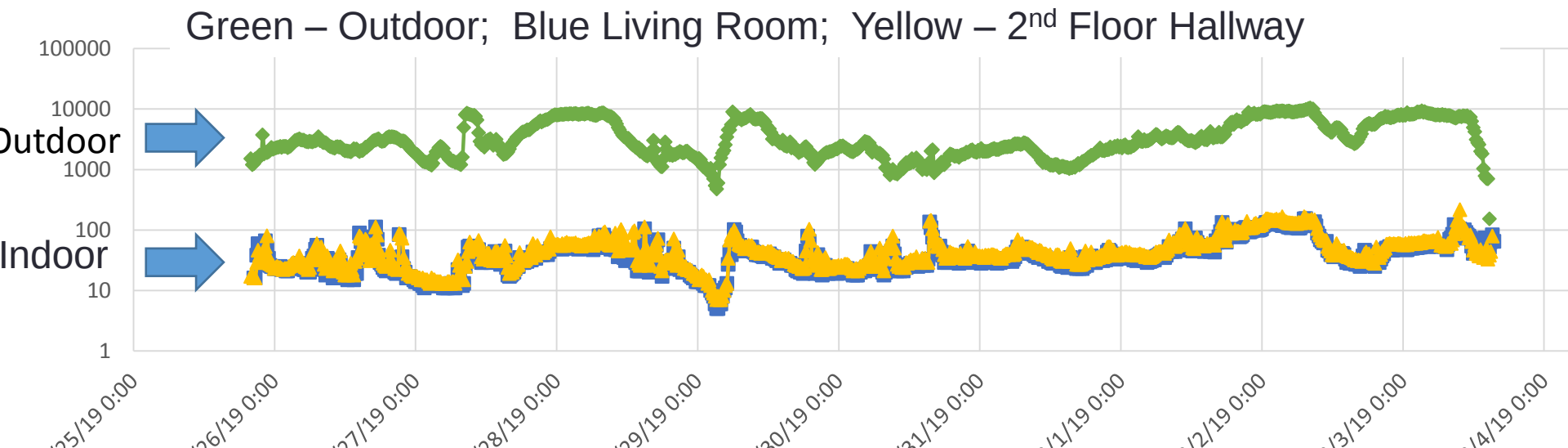


LCMP Top Performer Air Handler 24/7 – MERV 13 Filter

Indoor tracks outdoor
Indoor uniform – 2 locations
Also – 2nd fl portable air cleaner

Continuous Mode: **$12/month**
Post: 110 watts; 500 CFM
(Pre-Post: 400 watt reduction)

Dylos small (0.5+ microns) (#/1/100 ft^3)



Filter Bypass …Relatively Common

Photo credit: Brent Stephens