



INDOOR AIR QUALITY & HEALTH



Linda Wigington
Team Leader

Waynesburg, PA
lwigington1@outlook.com

www.ROCIS.org

Making the Connection: Home Hazards

GASP

6 – 7:30 PM; January 14, 2021

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.

01/14/2021

Making the Connection



Why??

Most of our exposure
to outdoor pollution
happens
IN buildings

<https://www.iaqscience.lbl.gov>



Focus on Particles

Also referred to as Particulate Matter (PM)

Particles (PM)



Dylos 1700
Our work horse!



Image courtesy of the U.S. EPA

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

➡ ROCIS LCMP Dylos: Particles > 0.5 μm
(1/100 of human hair!)

Pittsburgh's Air Quality is Poor

*People Most at Risk in the U.S. from **Year-Round** Particle Pollution (Annual $PM_{2.5}$)*

- 8th worst city
- Worst city east of the Rockies

...From Short-Term Particle Pollution (24-hour $PM_{2.5}$)

16th worst city¹ & worst city east of the Rockies

1. Pittsburgh-New Castle-Weirton (PA-WV-OH)

SOURCE: American Lung Association State of the Air Report 2020

<http://www.stateoftheair.org/assets/SOTA-2020.pdf>

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!

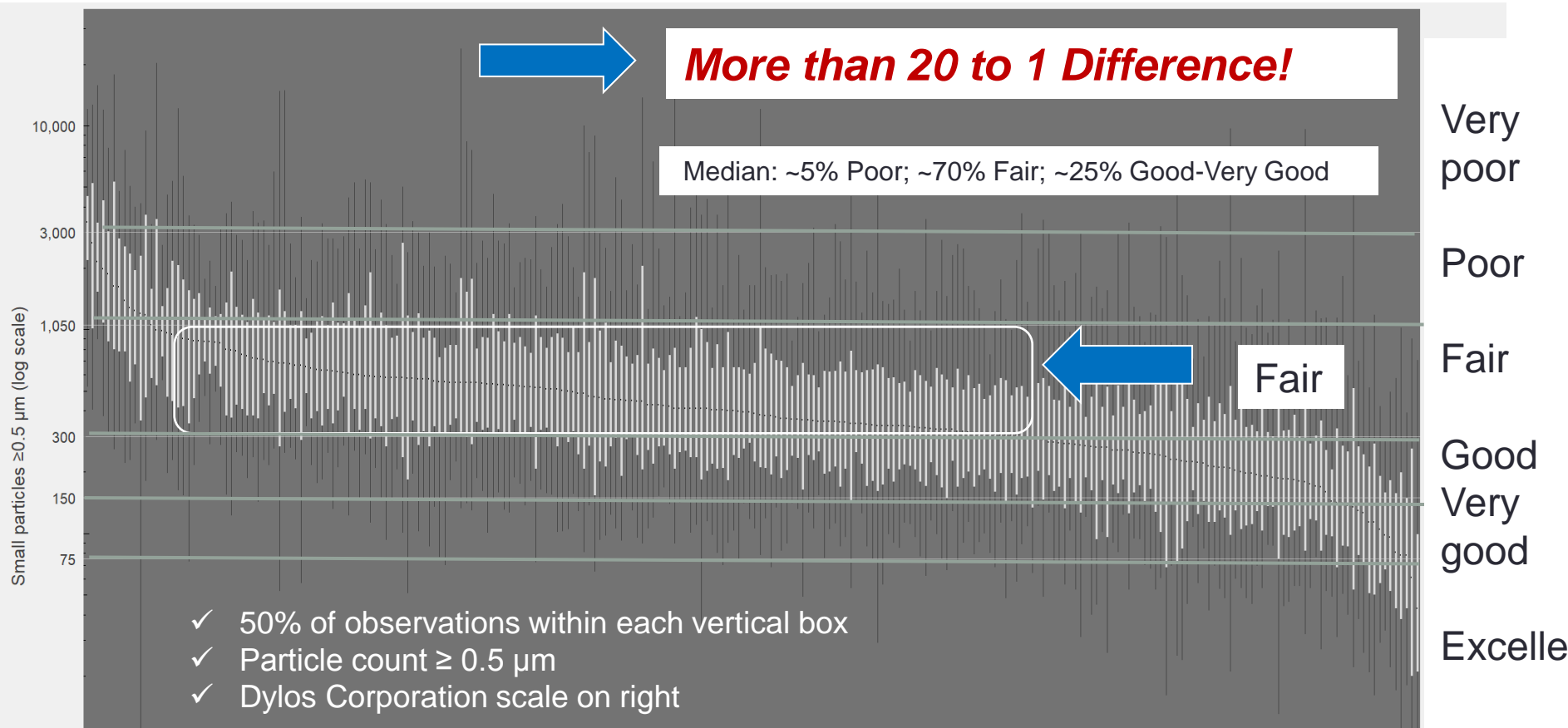


ROCIS LCMP

Low Cost Monitoring Project

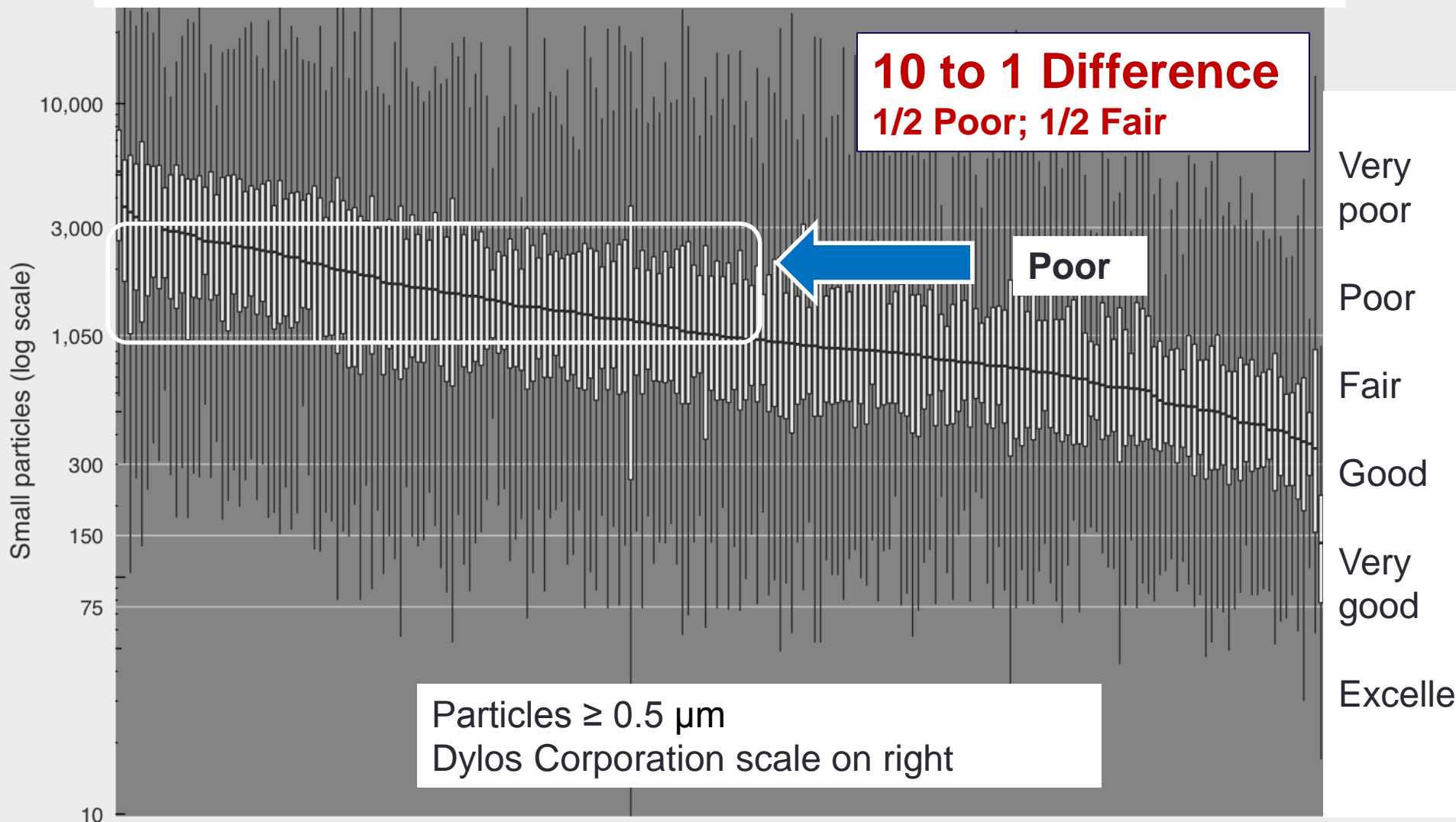
- Started 5 years ago
- Mostly homes, some work places
- 350+ participants
- Monitor particles, radon, CO₂, & CO
- 3-4 week monitoring period

Indoor Particle Distribution – 250 LCMP Residential Sites



For additional information: <http://rocis.org/past-rocis-events>

Outdoor Particle Distribution – All Sites



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

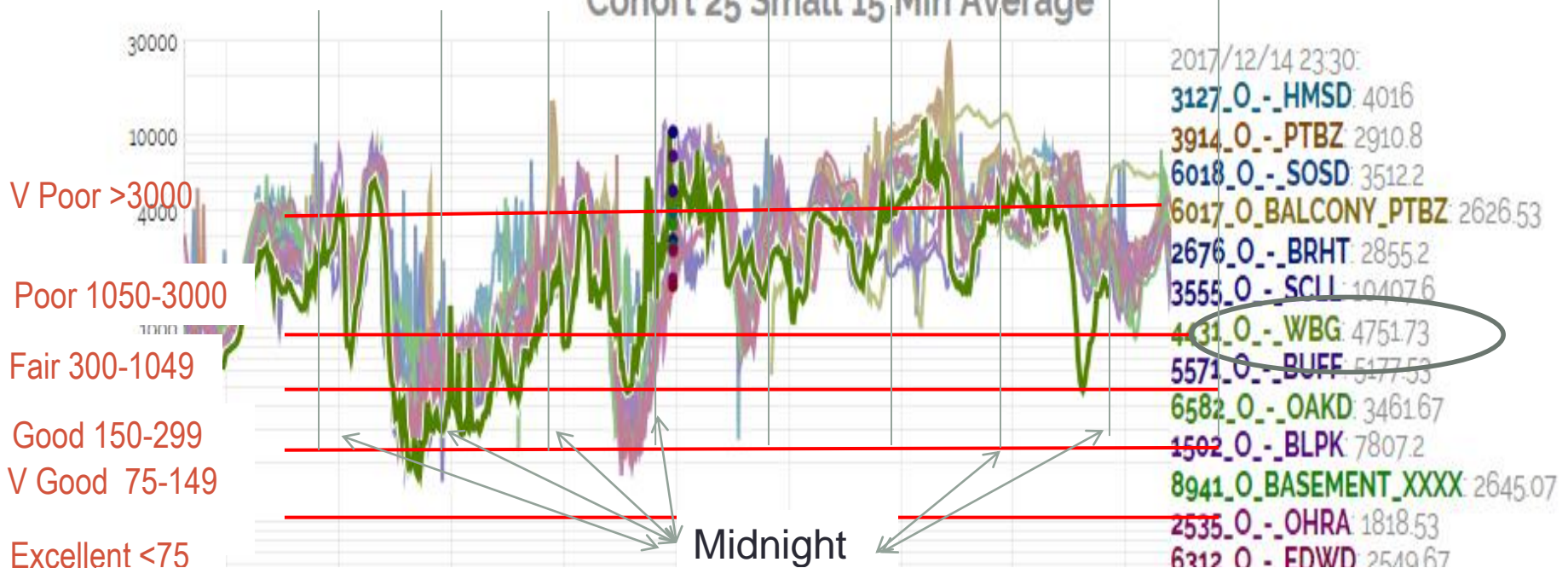
- **Reduce air exchange from outside**
 - Close windows
 - Tighten home or building
- **Reduce indoor sources**
 - Use an effective ducted kitchen hood!
 - Use induction cook top & other good practices w/ cooking
- **Reduce resuspension**
 - HEPA vacuum
 - Walk-off mats
 - Get rid of carpets, old upholstered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

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

Log scale

ROCIS Low Cost Monitoring Project

Cohort 25 Small 15 Min Average



We share the same air shed!

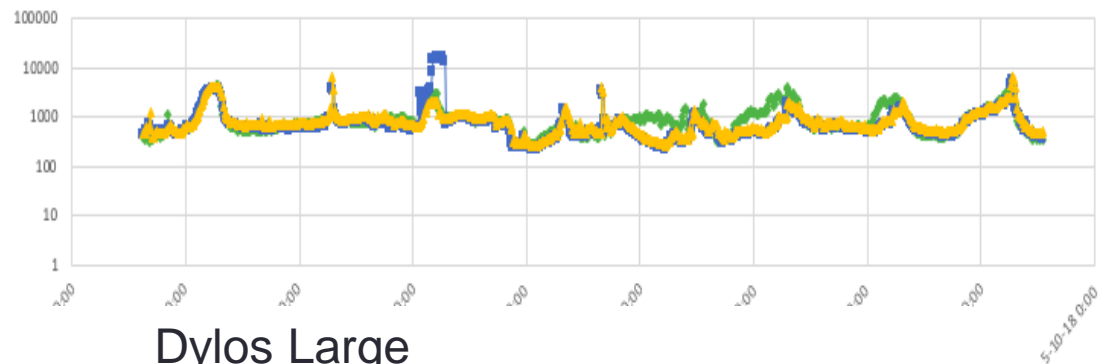
Rapid variations in outdoor particles – particularly worse at night

L27

House with Wide Open Windows

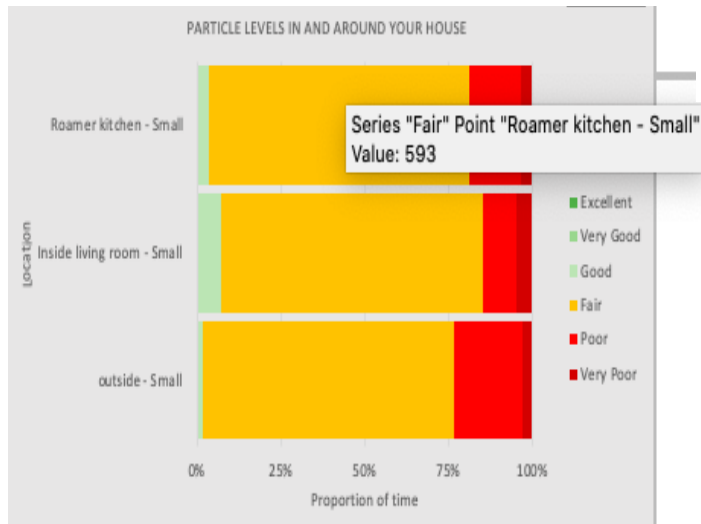
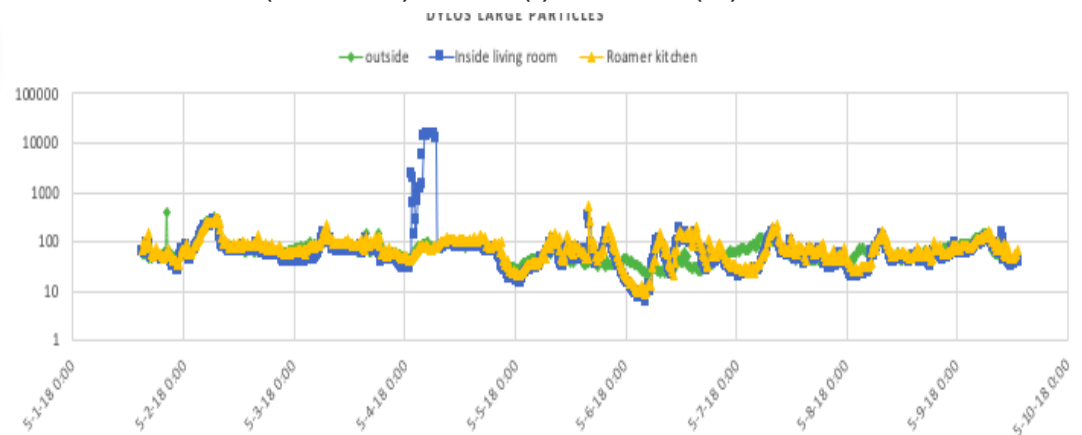
Dylos Small

Green (Outside); Blue (I); Yellow (R)



Dylos Large

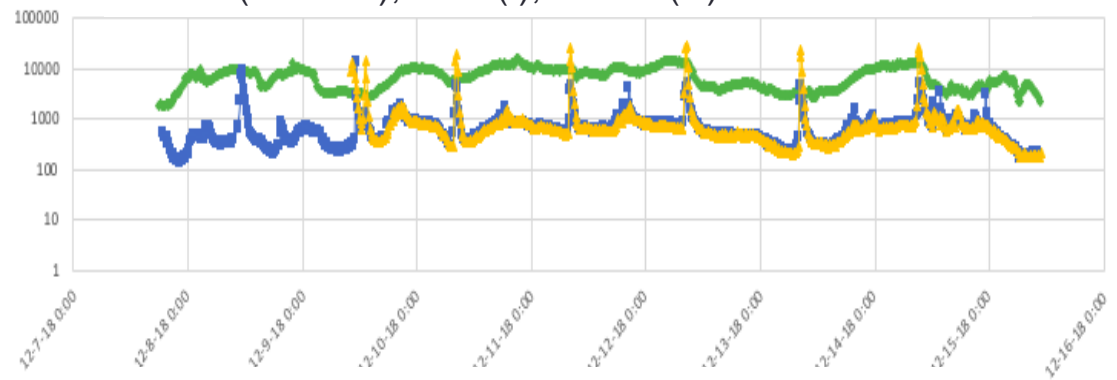
Green (Outside); Blue (I); Yellow (R)



1941 House in Winter with High Outside Particle Counts

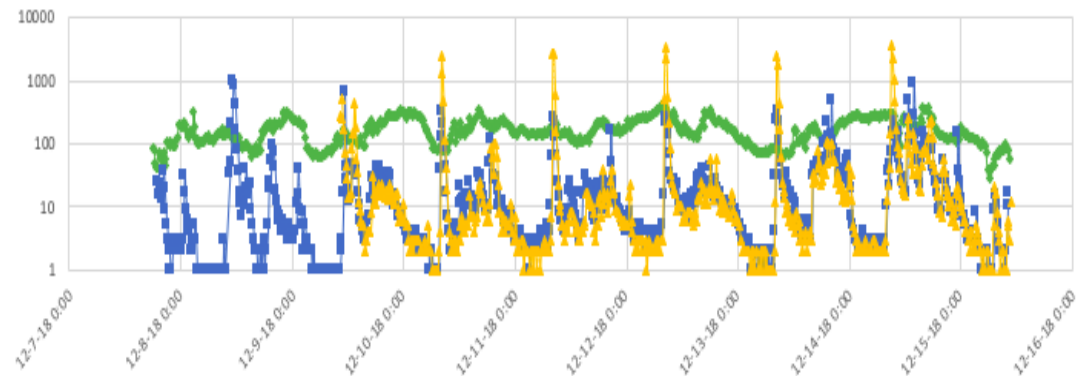
Dylos Small

Green (Outside); Blue (I); Yellow (R)

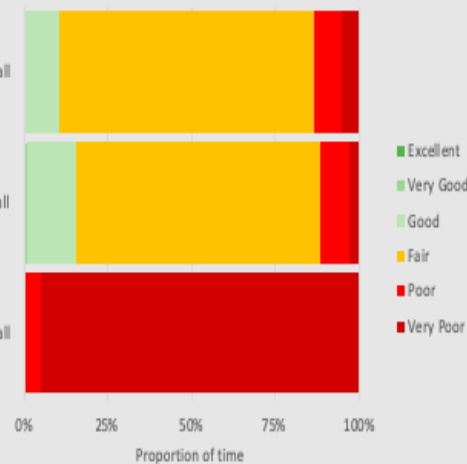


Dylos Large

Green (Outside); Blue (I); Yellow (R)

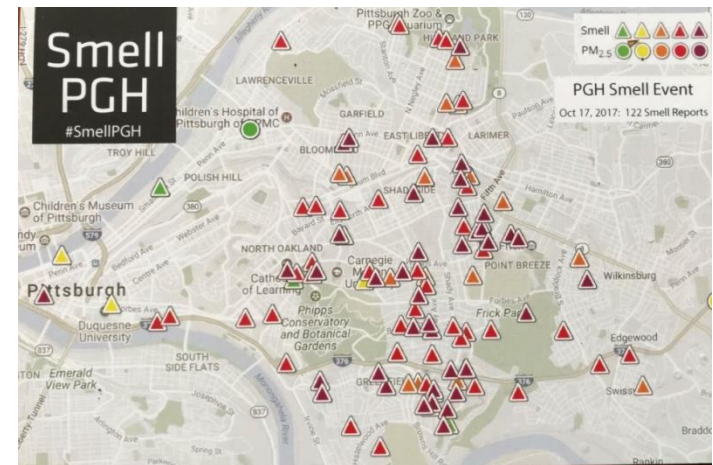
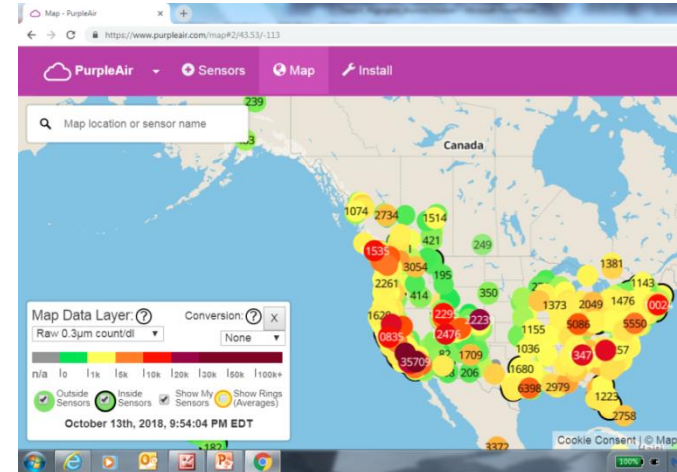


PARTICLE LEVELS IN AND AROUND YOUR HOUSE



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

- 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
 - Walk-off mats
 - Get rid of carpets, old upholstered furniture
- Filter the air
 - Portable air cleaners
 - 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

Reducing Cooking Emissions

Check out ROCIS guidance document, webpage, & Dec. 2020 webinar

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

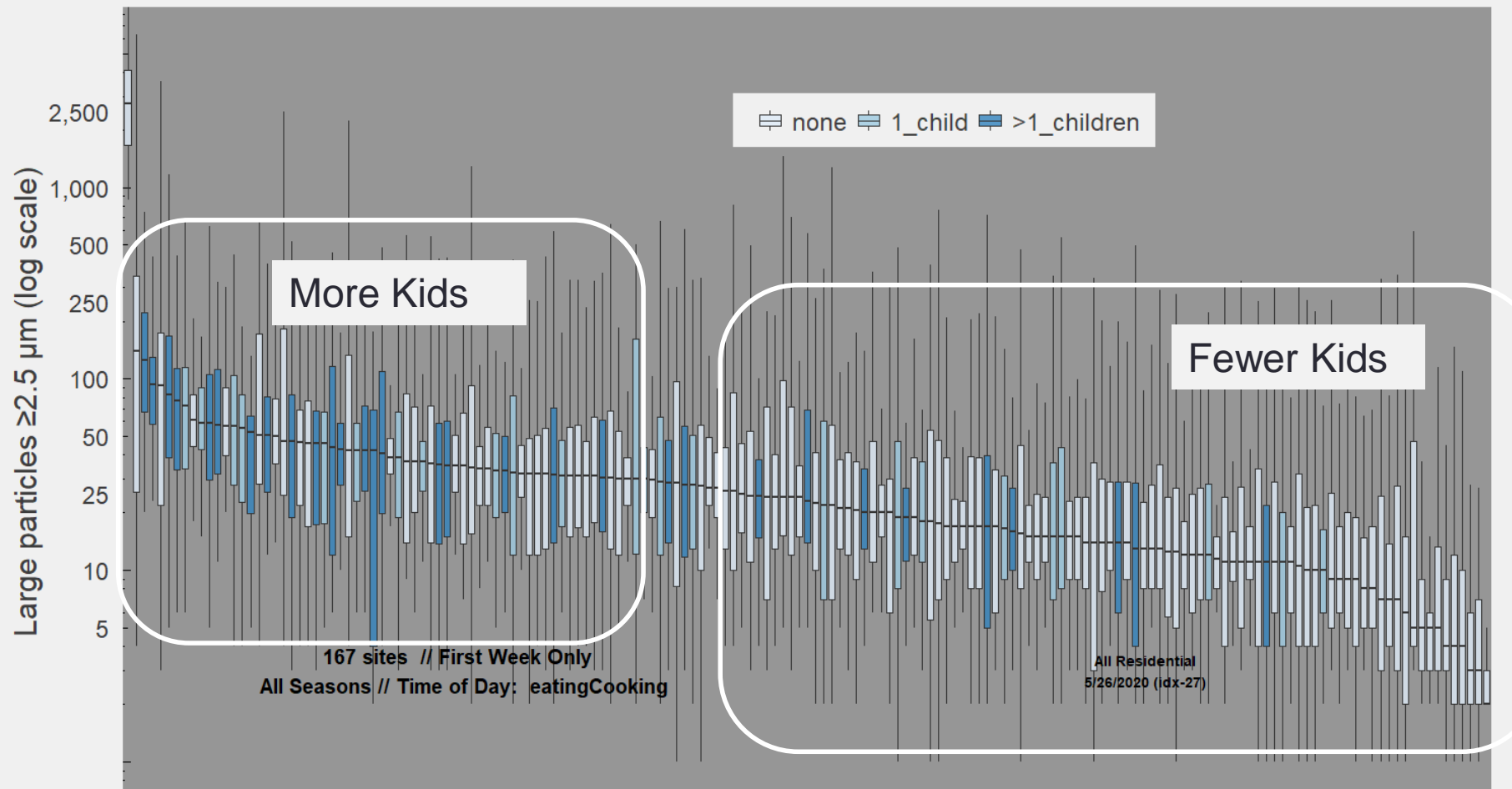


4 Strategies to Reduce Indoor Particles

- 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
 - Walk-off mats
 - Get rid of carpets, old upholstered furniture
- Filter air
 - Portable air cleaners
 - Central air handler (furnace, AC, or ventilation)

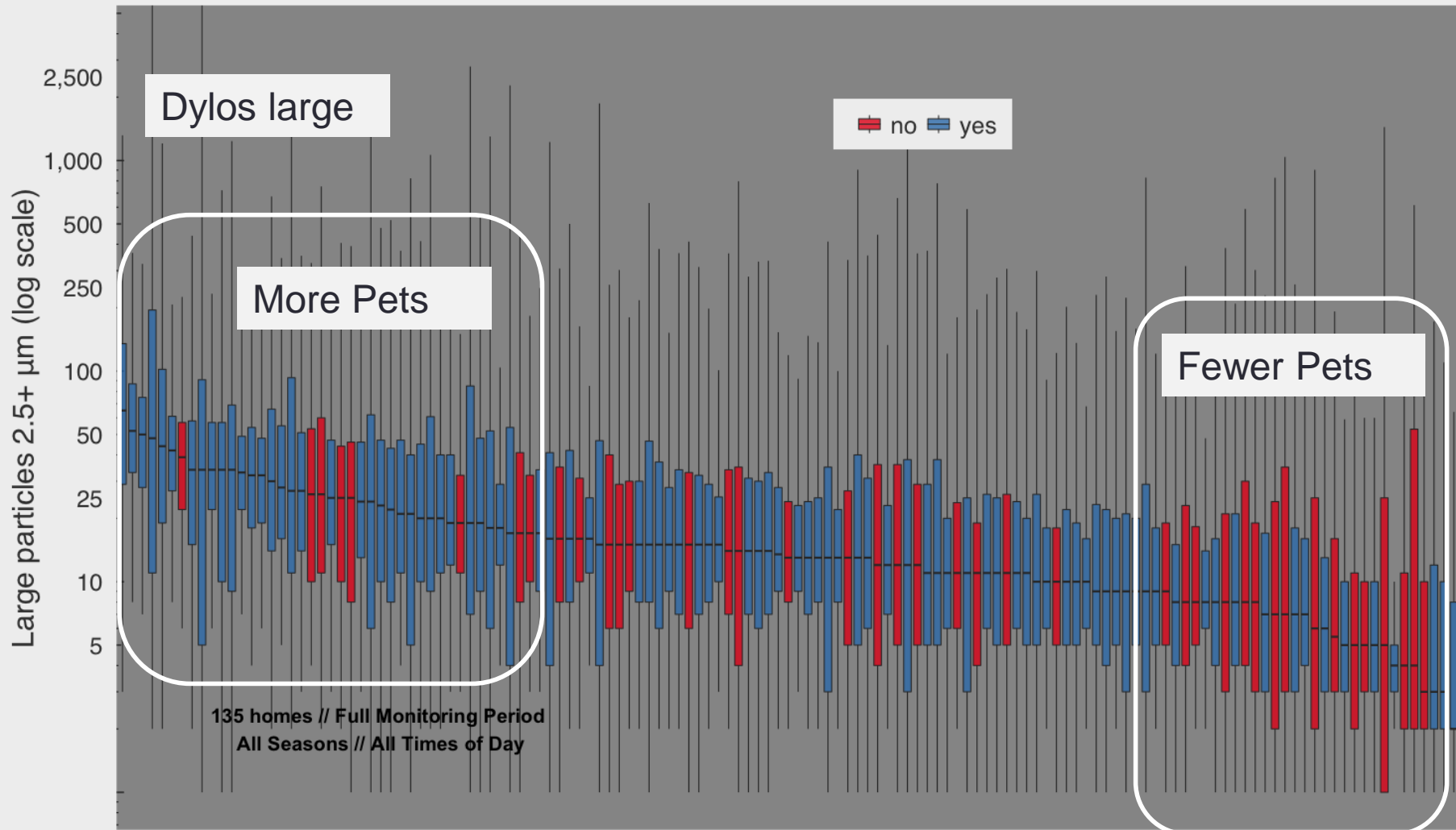
Number of CHILDREN LIVING THERE?

Large Particle Levels: Indoor



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?

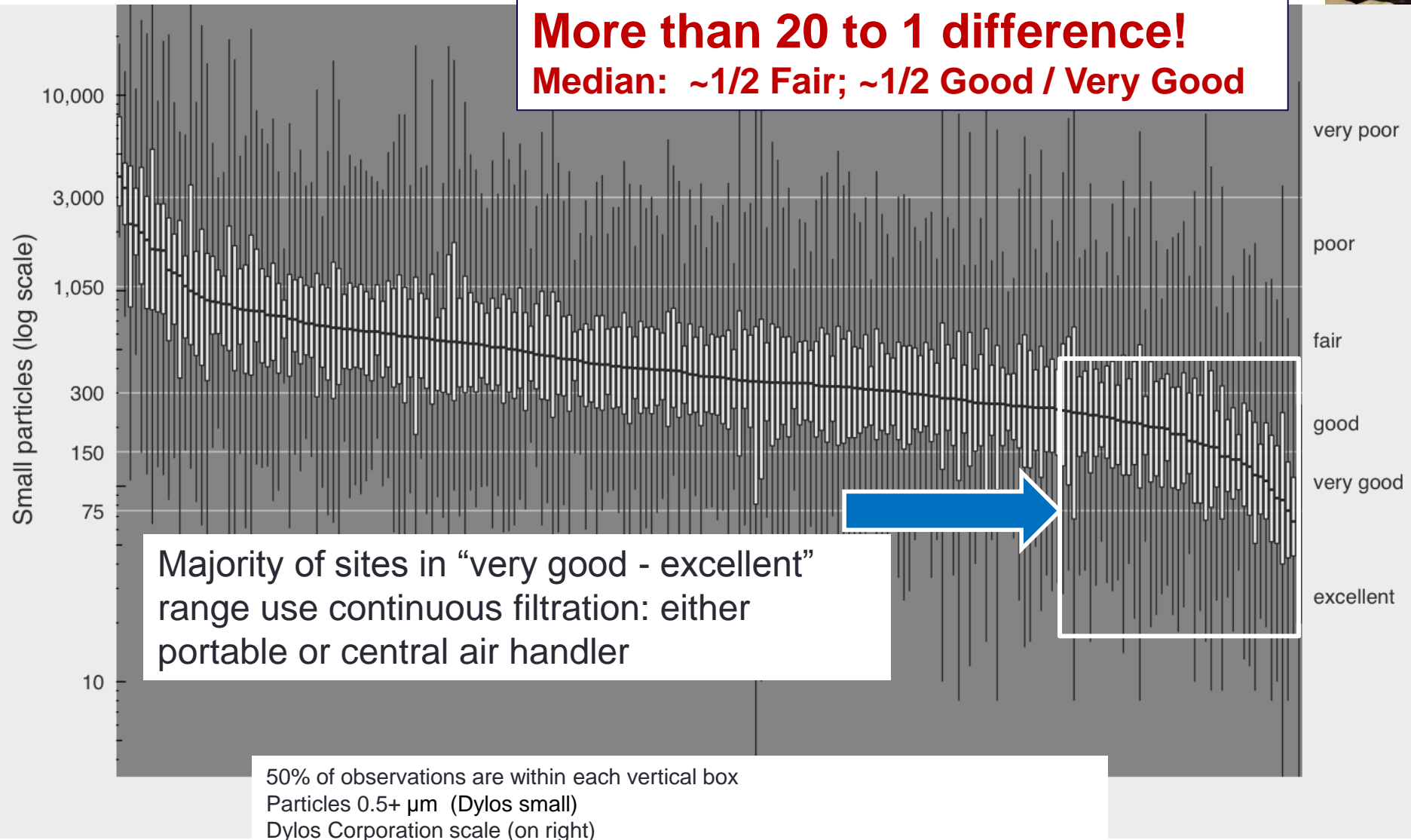
4 Strategies to Reduce Indoor Particles

- **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
 - Walk-off mats
 - Get rid of carpets, old upholstered furniture
- **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



Portable Air Cleaners

Also referred to as Air Purifiers

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 (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 oversize)



Clairton Air Filter Distribution Program

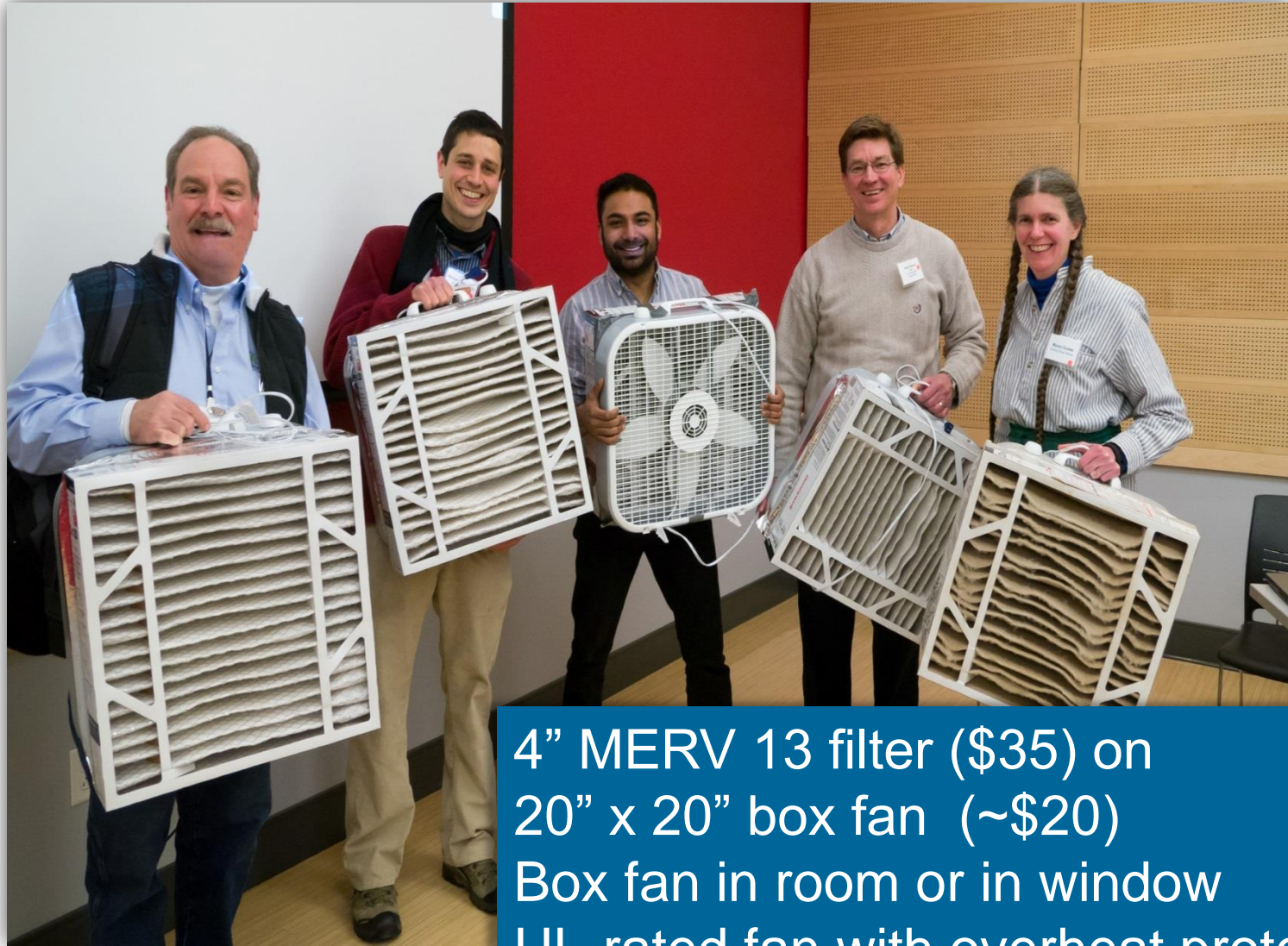
Summer 2020

- 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>

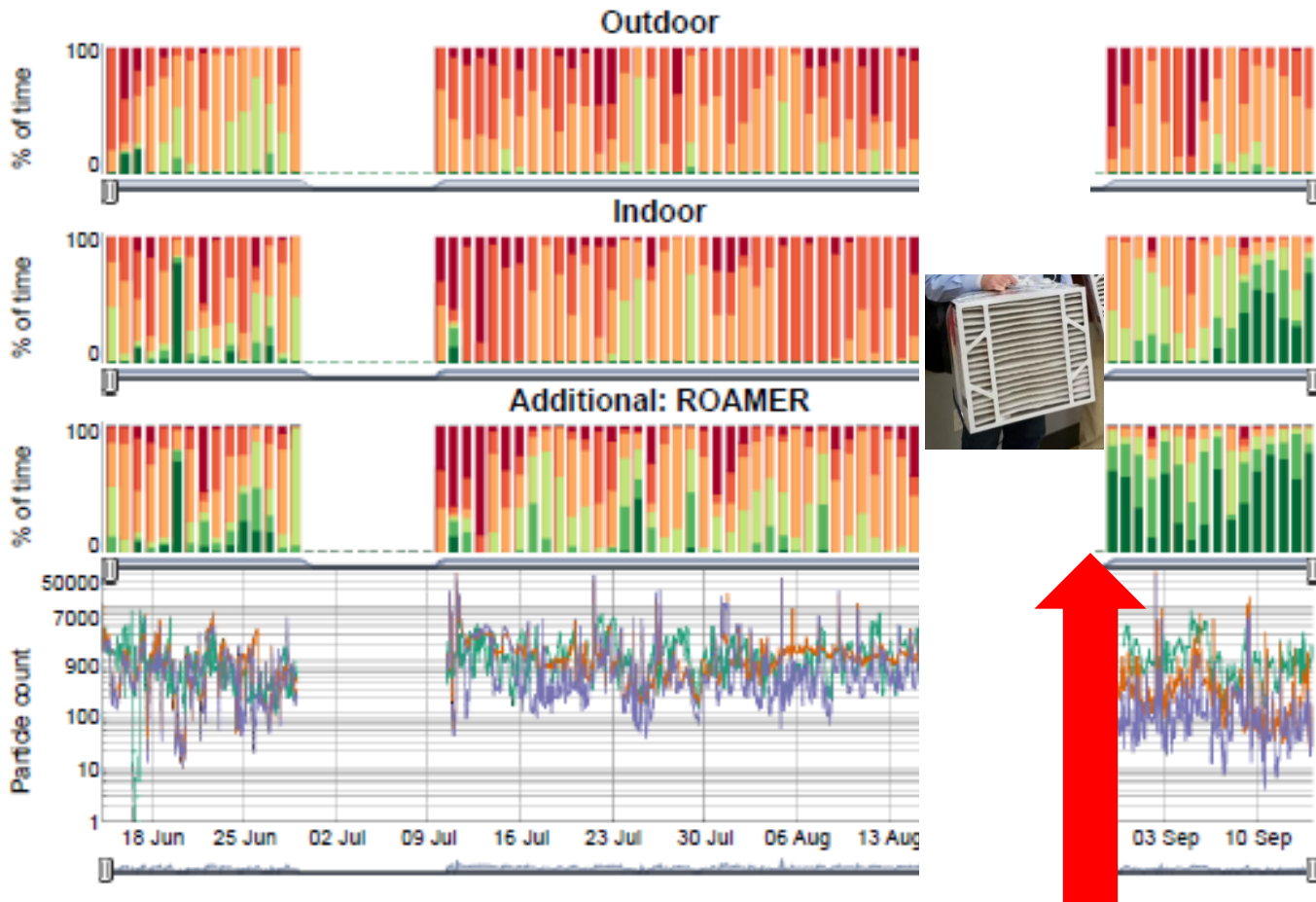
DIY Fan Filters

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



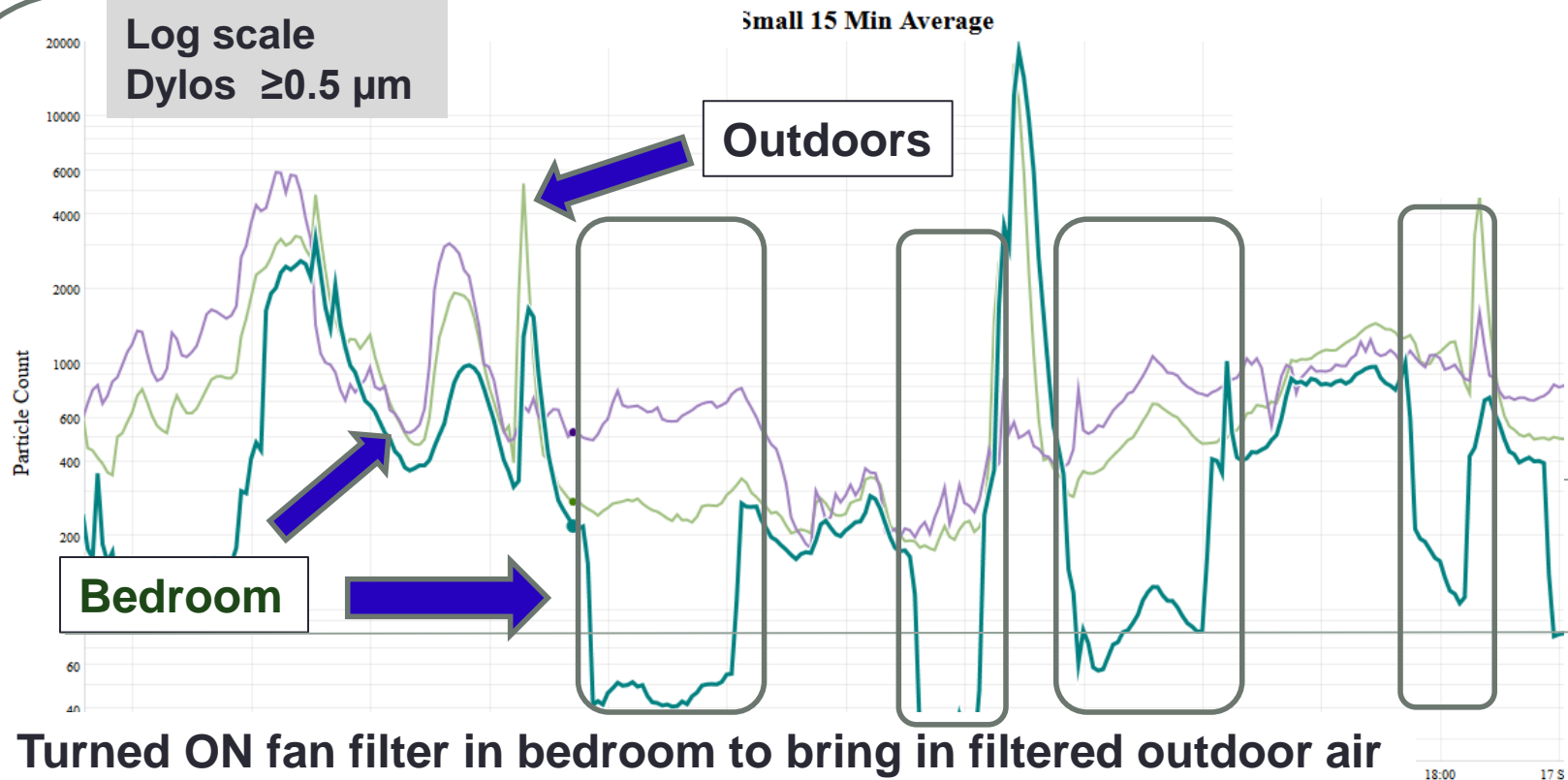
<http://rocis.org/rocis-data-explorer> (k4x3)

Added fan/filter here

Fan/Filter Intervention— Bedroom Window at Night

Open window with/without box fan & filter on:

Indoor tracks outdoor closely



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...

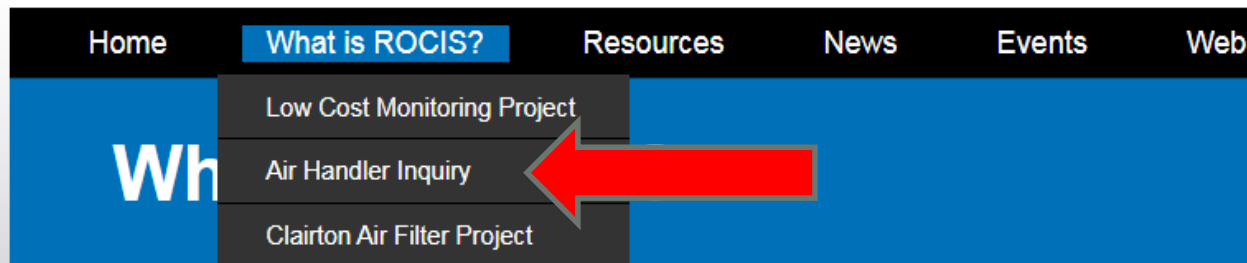
Is there an **easy way** to determine if I can use a high MERV filter with a **longer air handler run-time** without causing problems (\$, equipment durability, performance, or GHG emissions)?

NO !!

Diagnostic Screen is Required

ROCIS 24/7 Air Handler Checklist

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



ROCIS Mission

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/year¹)

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

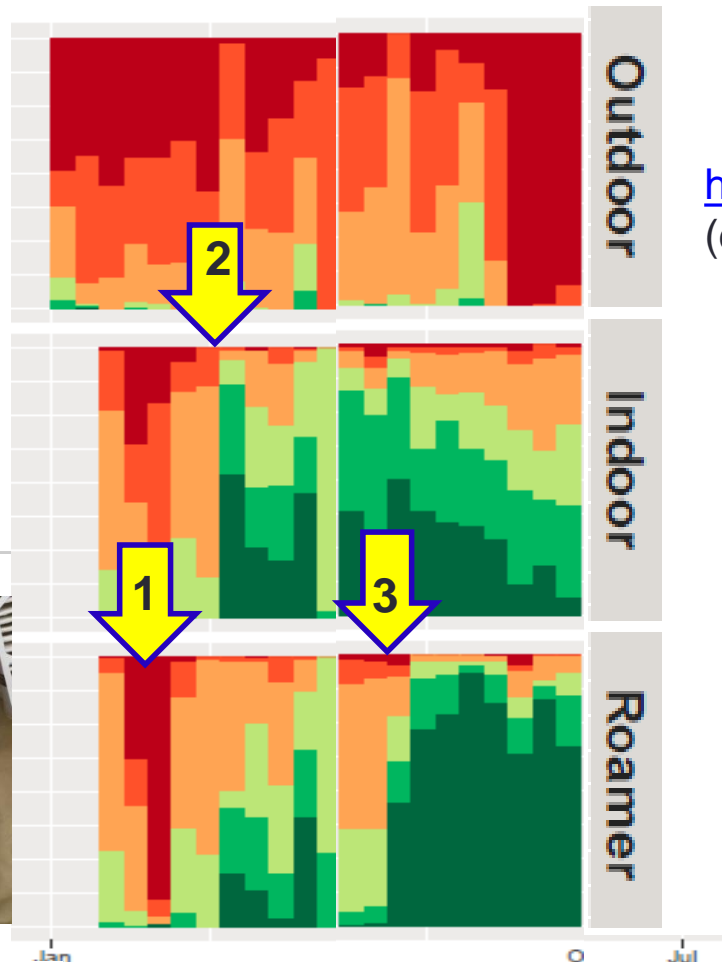
Big Opportunity at HVAC Replacement

- ***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

Behavior *Plus* Technical Intervention

Motivated Occupant

dylosCat



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)

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>

SUMMARY

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

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



Linda Wigington

Project Lead,
ROCIS Initiative
724-852-3085

lwigington1@outlook.com

<http://ROCIS.org/>

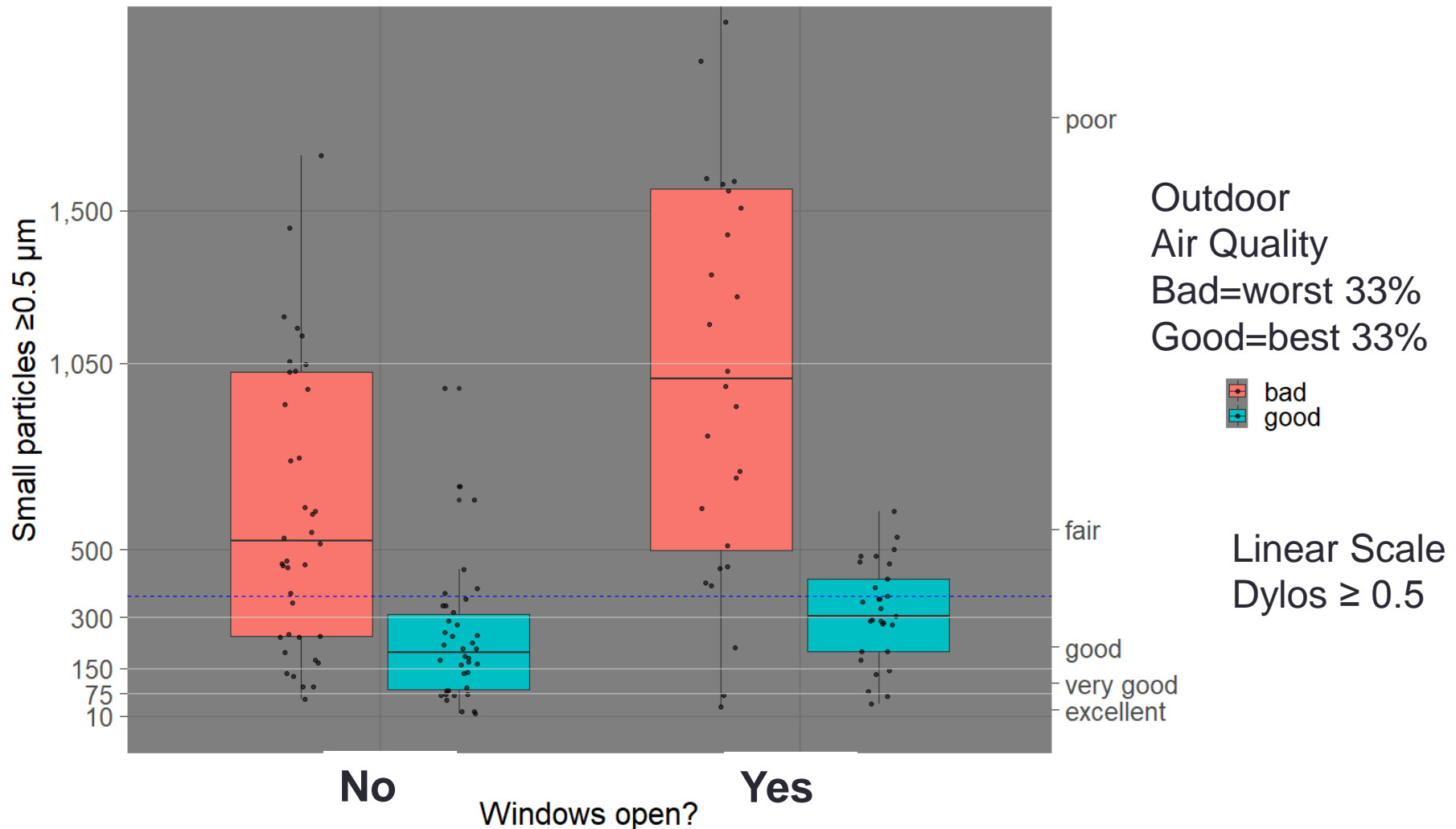
EXTRAS

INSIGHTS FROM ROCIS MONITORING DATA

Indoor Particle Levels

Tendency to Open Windows Compared to Outdoor Particle AQ

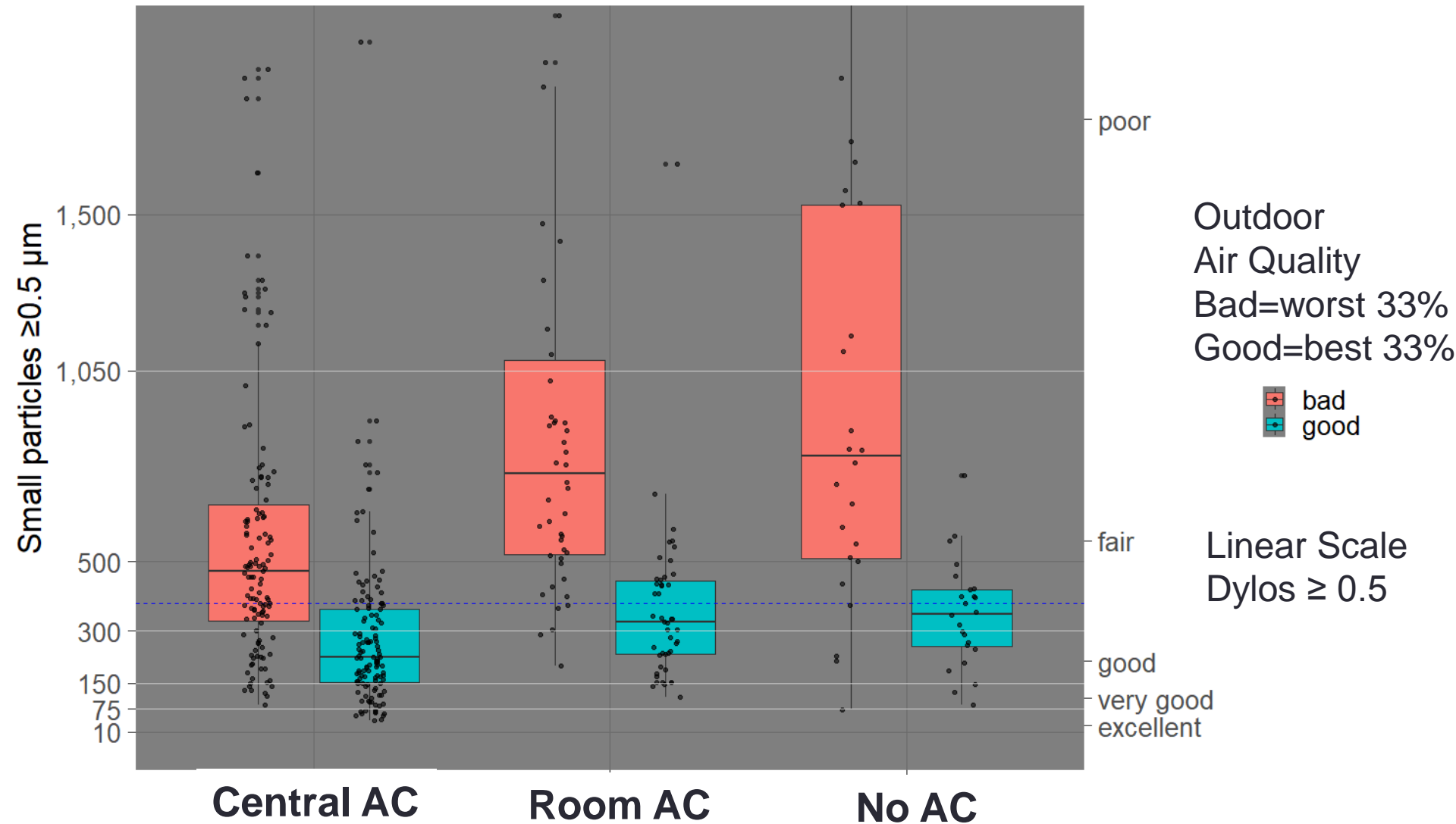
sleeping hours, summer season



Indoor Particle Levels

Air Conditioning Type by Outdoor Particle AQ

all TOD, all seasons



4 Conclusions

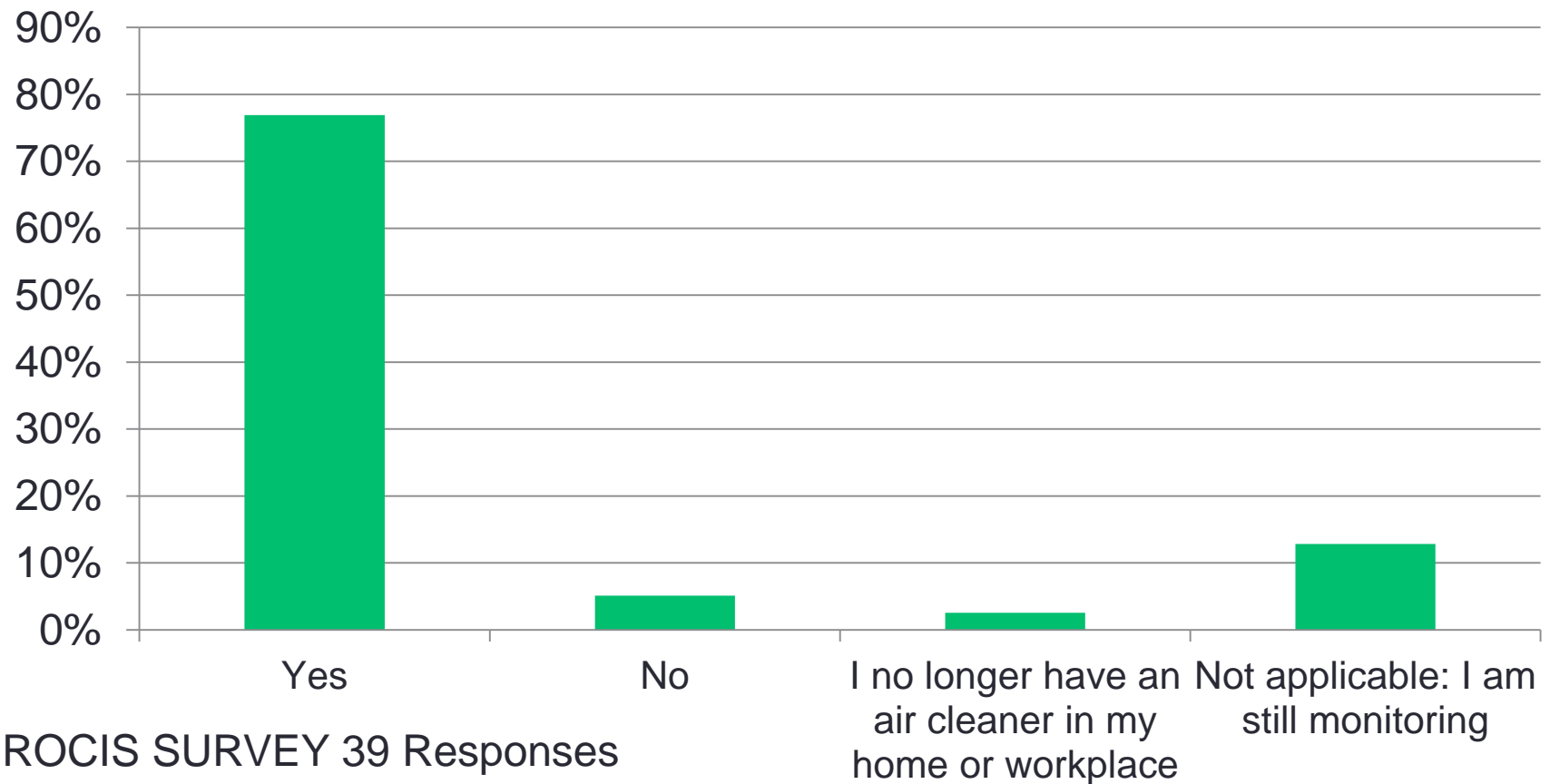
1. **Low cost monitors - reinforce behavior & investment**
2. **Less outdoor particle pollution - much less indoor levels**
3. **Occupants & building systems - significant impact on particle levels**
4. ***Better outdoor air quality & housing stock/building systems - critical to reduce disparities &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

INSIGHTS / RESULTS FROM ROCIS INTERVENTIONS

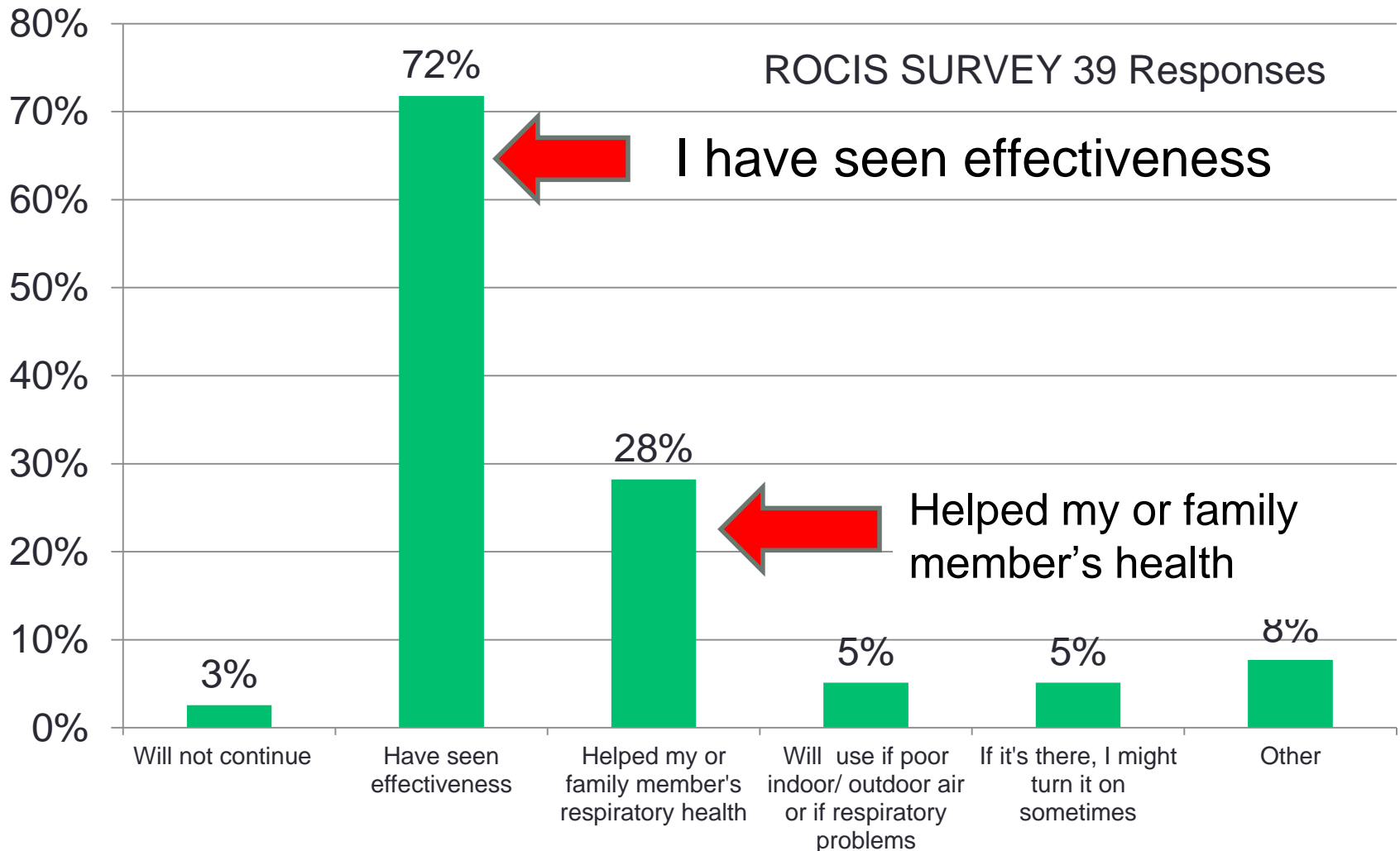
Portable Air Cleaners

Also referred to as Air Purifiers

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



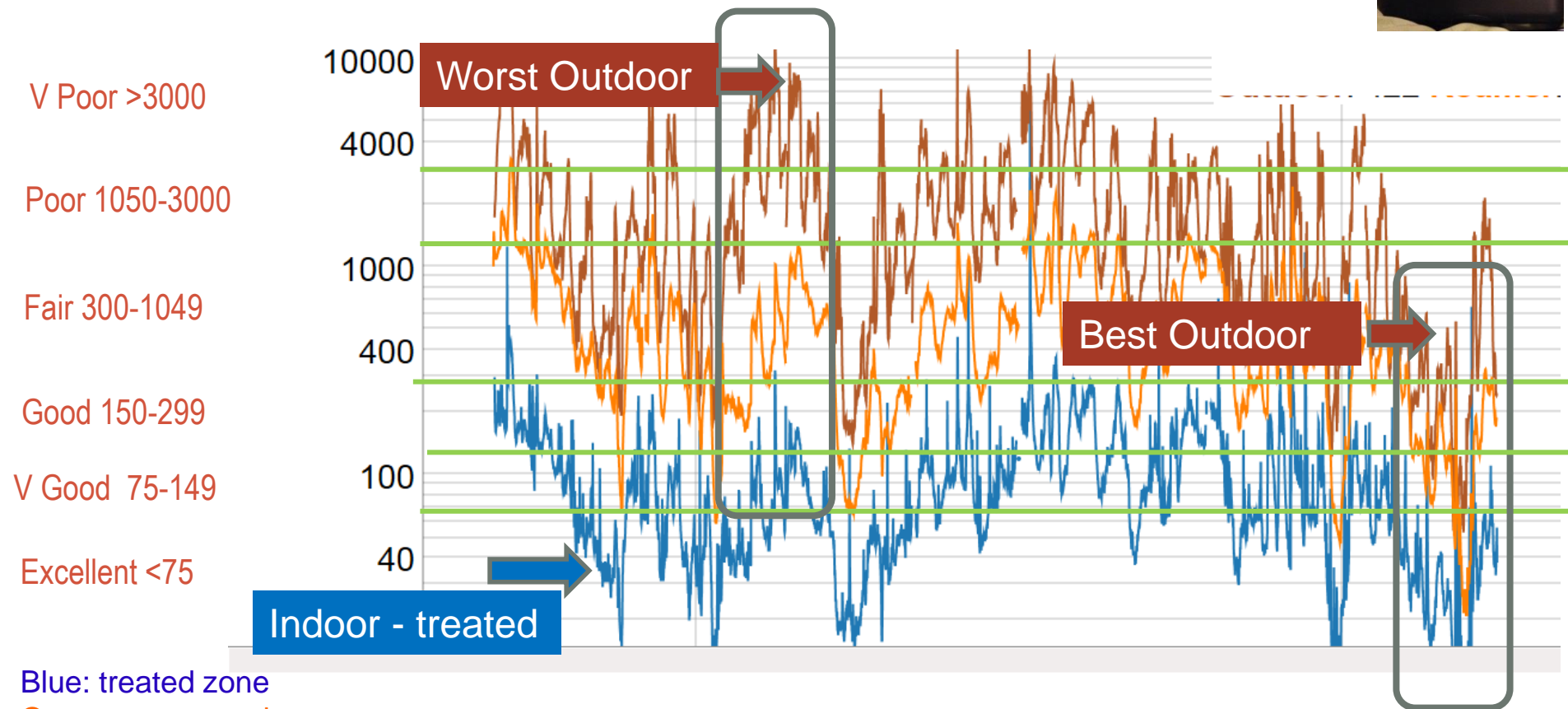
Why Continue to Use an Air Cleaner or Fan/Filter?



Online Data Explorer

Indoor Counts Track Outdoors

<http://rocis.org/rocis-data-explorer> (j1t8) $\geq 0.5\mu\text{m}$ Particles by Time (15-min. avg.)



Blue: treated zone

Orange: untreated zone

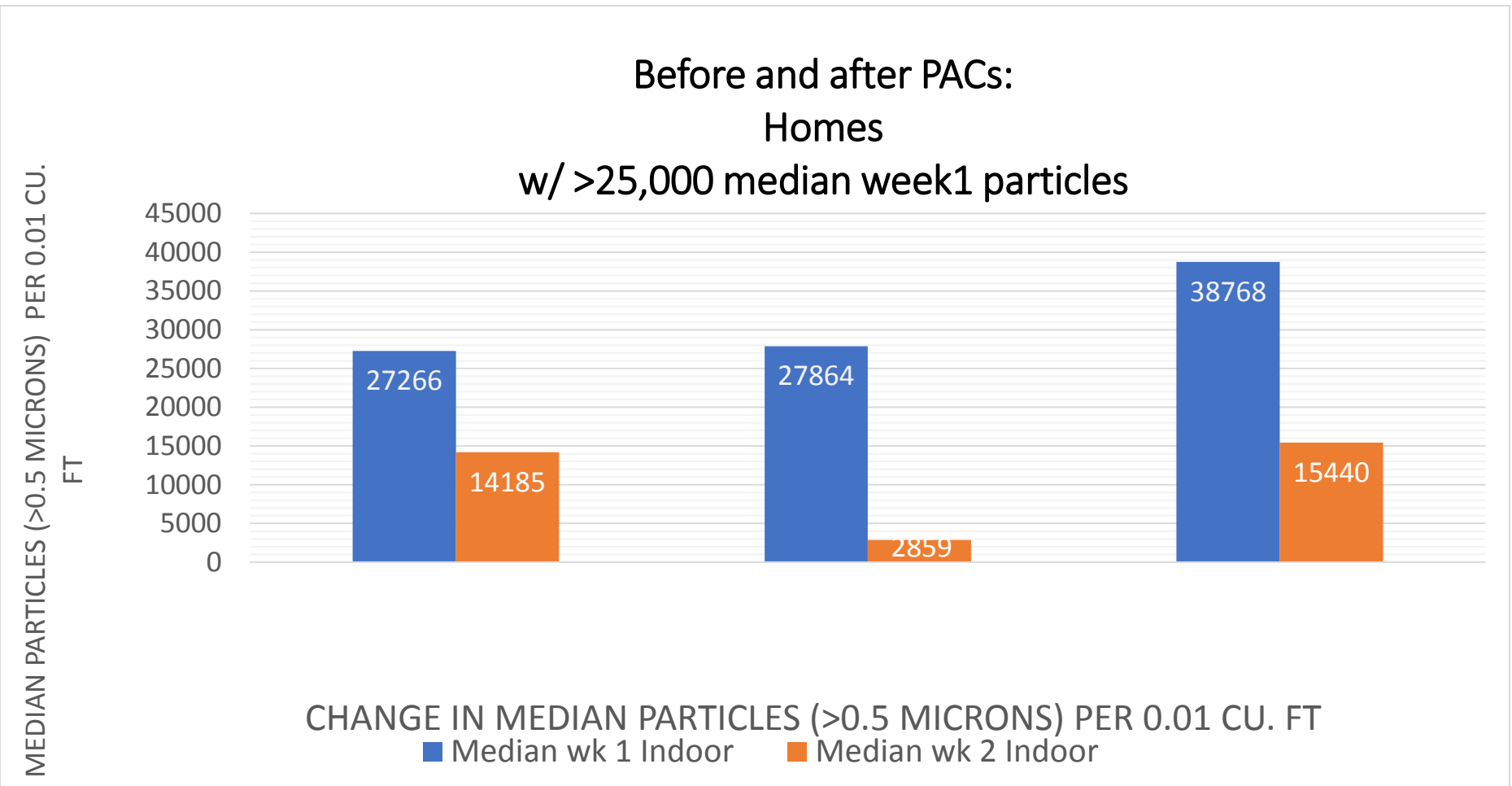
Deep red: outdoors

Tight, single family home

Though order of magnitude lower; Indoor (Blue/orange) tracks Outdoor

Clairton Air Filter Project

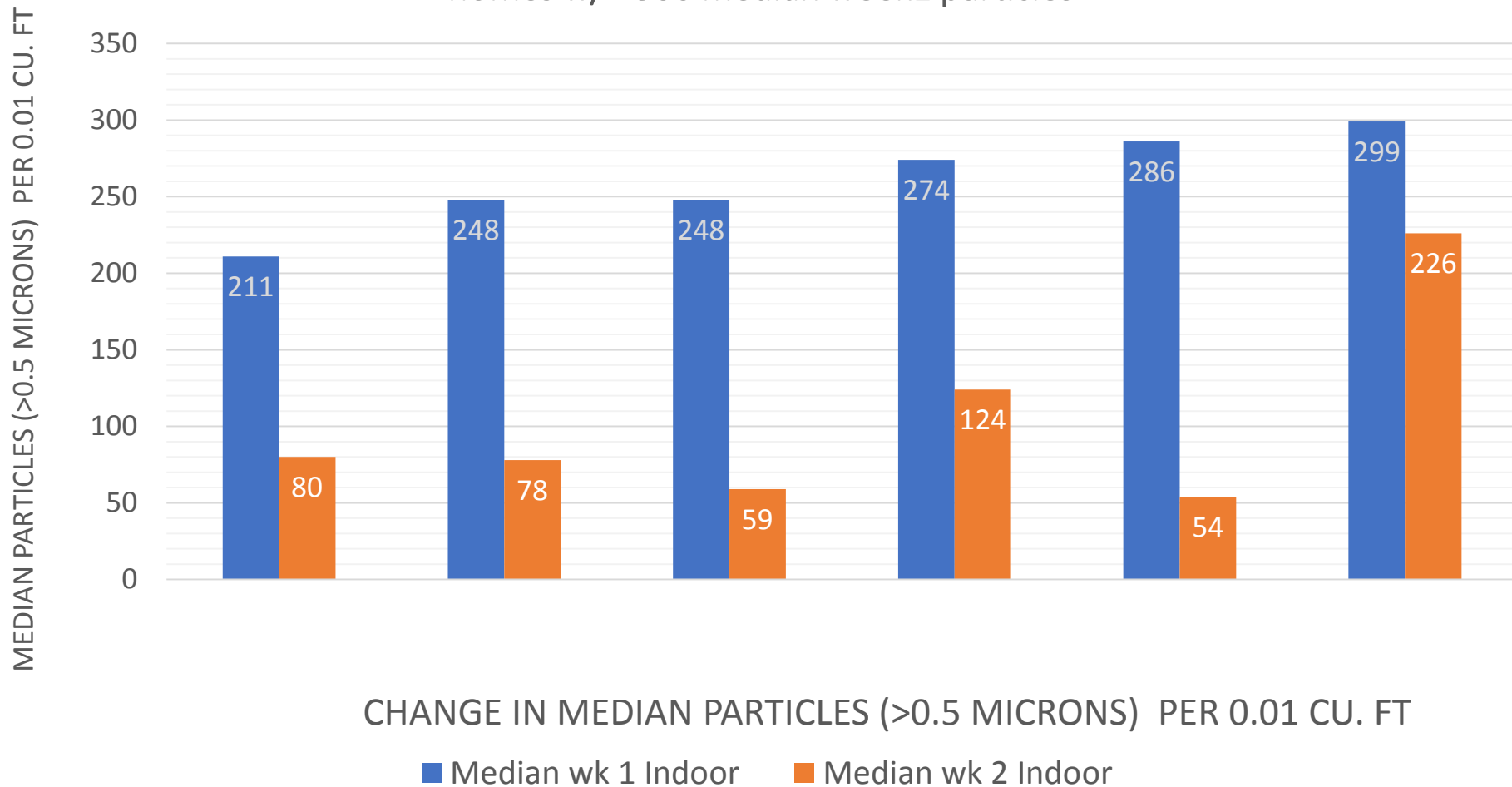
Reductions – Very High Pre-Particles



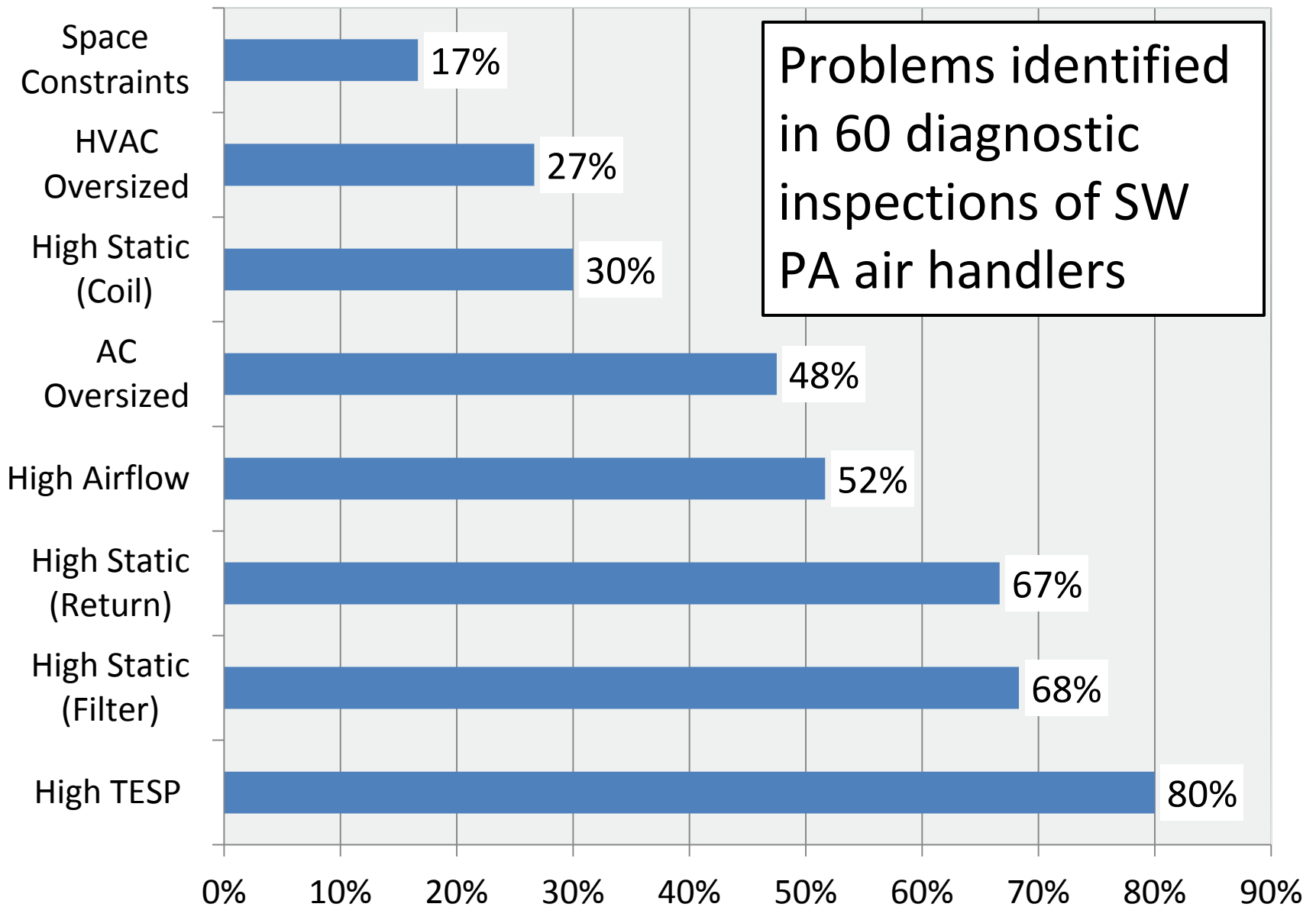
Clairton Air Filter Project

Reductions: Low Pre-Particle Count

Before and after PACs:
homes w/ <300 median week1 particles

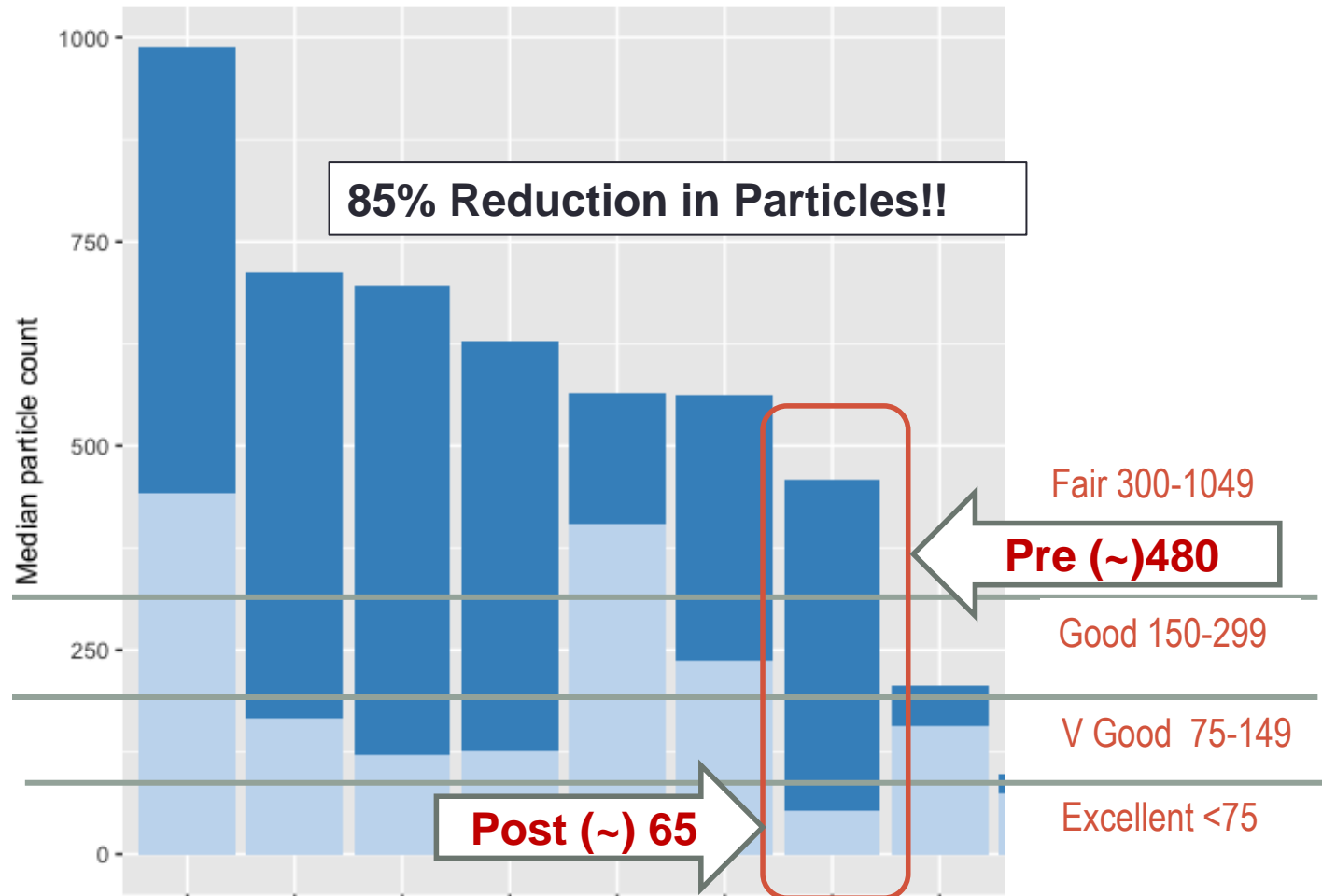


Air Handler/high MERV Inquiry



Selected ROCIS Intervention Homes

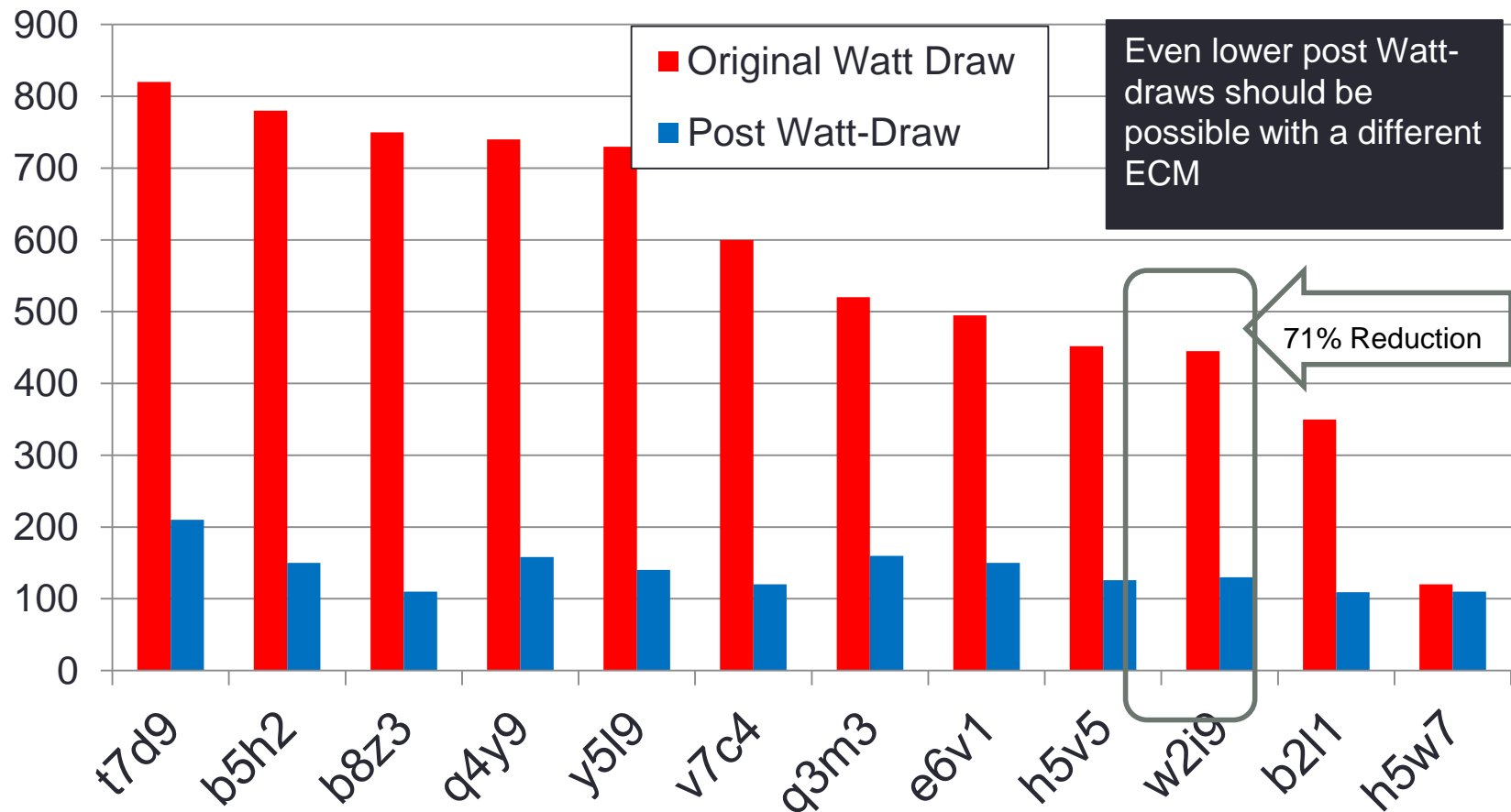
Pre-Post Median Particle Count



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

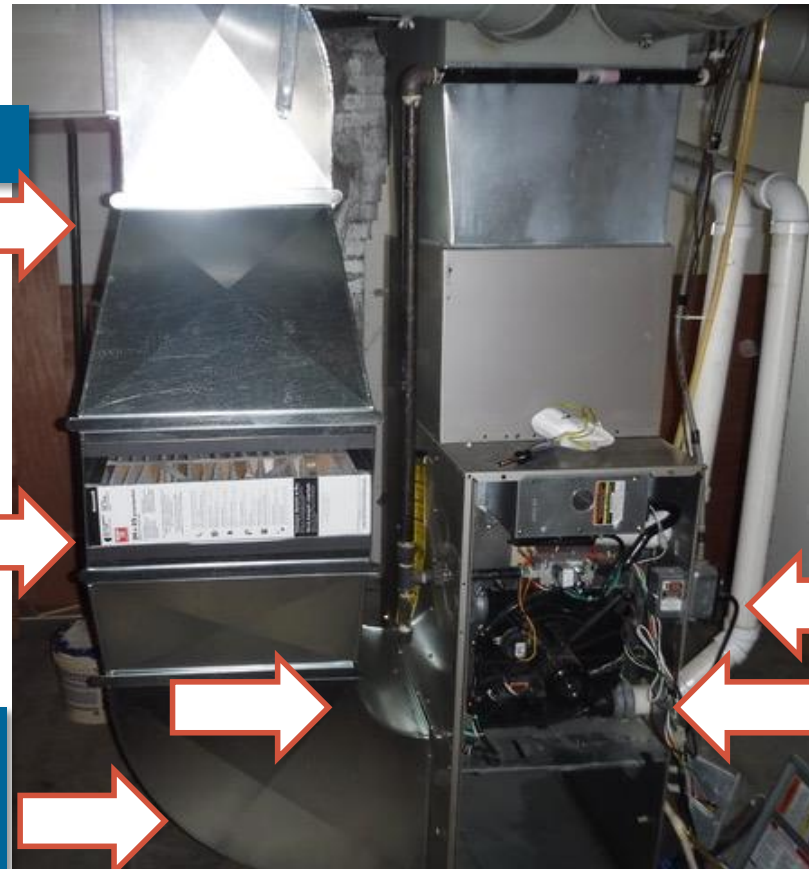
Air Handler Interventions

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

RESULTS:

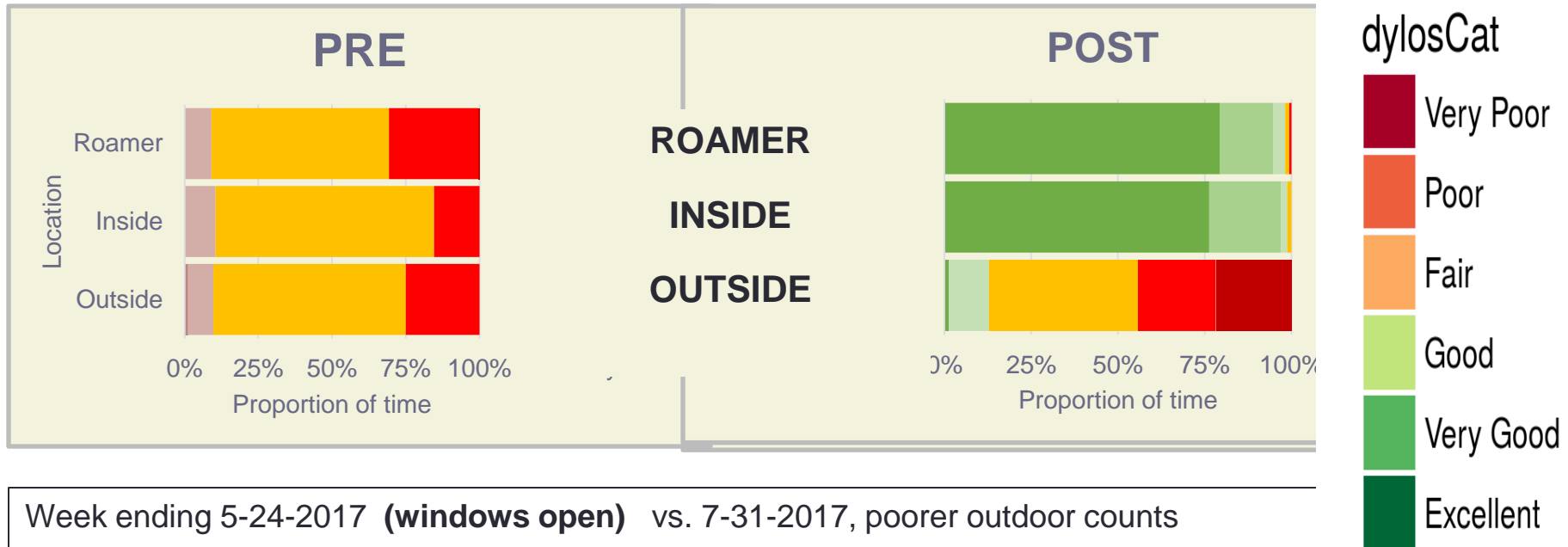
In continuous mode:

- 4.27 CFM/watt
- 120 Watts
- Pressure drop across filter
Pre: 93 Pa, Post: 16 Pa
- **Allowable TESP: 125 Pa**
(total system)

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

Case 2 Pre & Post Particles

Air Handler Retrofit



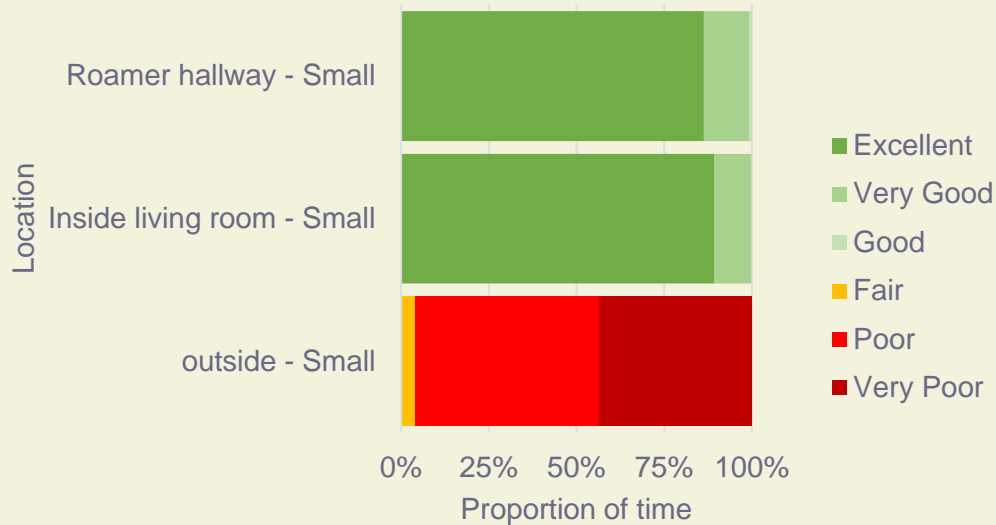
INTERVENTION:

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

PARTICLE LEVELS IN AND AROUND YOUR HOUSE

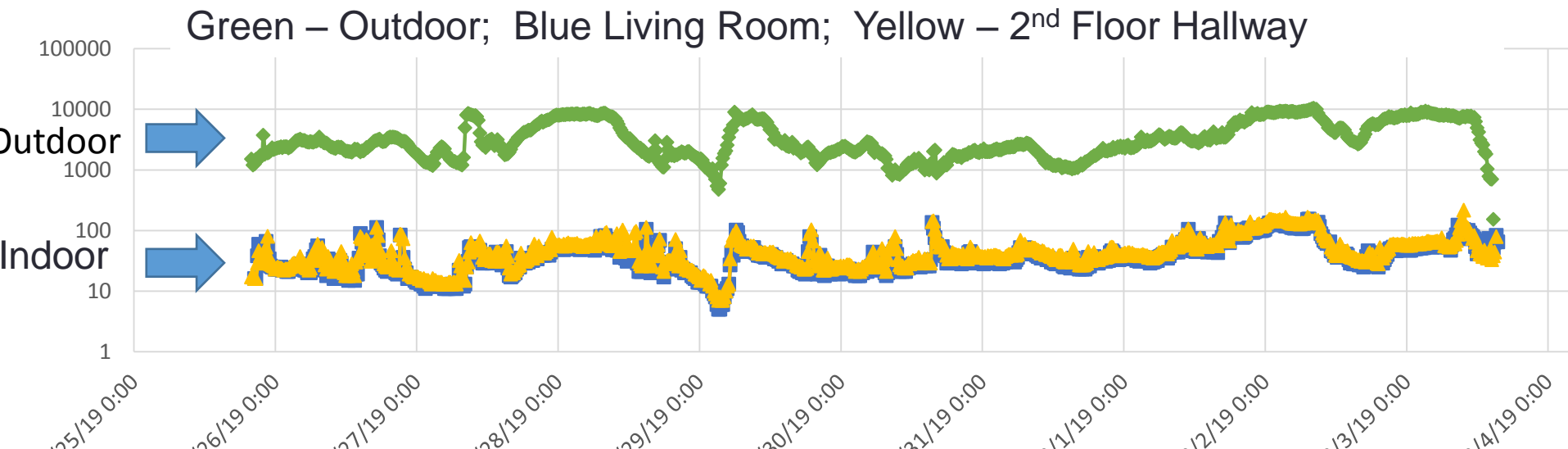


LCMP Top Performer Air Handler 24/7 – MERV 13 Filter

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 ft³)



Filter Bypass ...Relatively Common



Better the filter the greater the adverse impact!

Photo credit: Brent Stephens