The Speck Monitor

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CREATE Lab: Community Robotics

Who cares about air?

Asthma
Allergies
New parents
Heart disease
Extraction Industry
QS users

What can we do about bad air?

Speck measures indoor PM2.5 and displays Air Quality

Touch Sensitive Screen

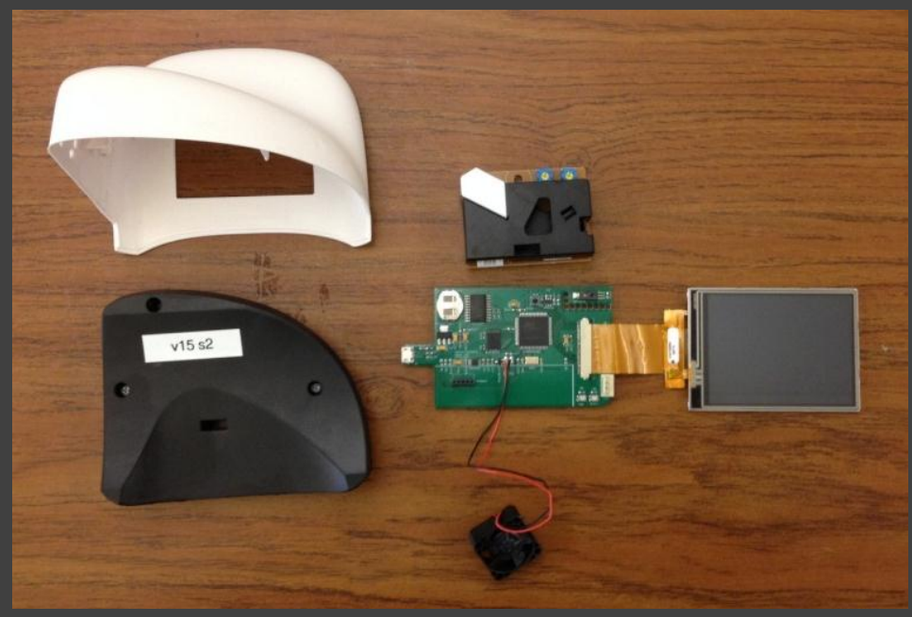
Automatic Wi-Fi Data Upload

USB/AC powered

Report indoor and outdoor AQI

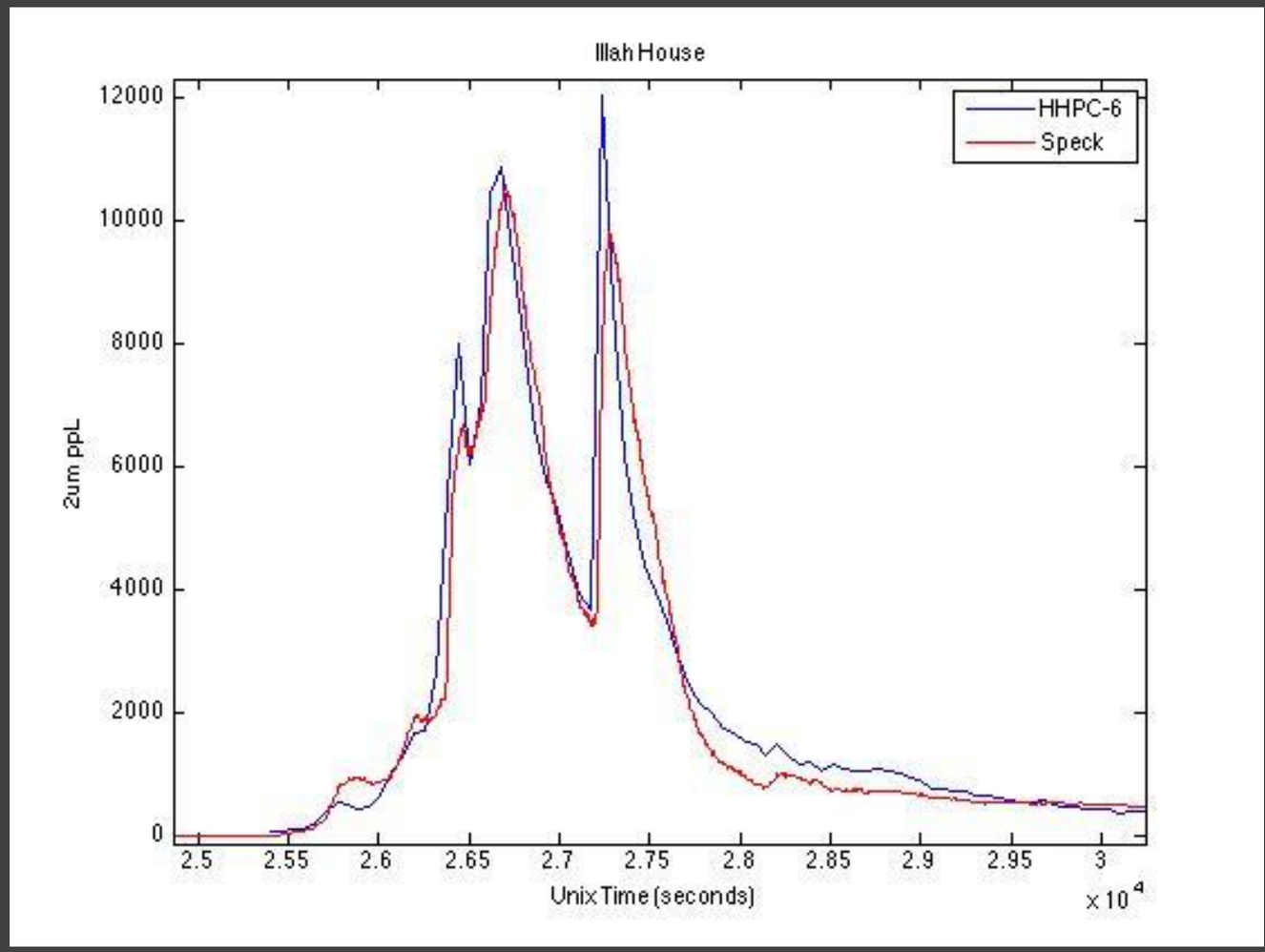
Cost

- 36 discrete parts
- BOM, U.S. build & assembly: $69 x1000
- Price dropoff:
  - TFT display $15; uController $8; fan $6; enclosure $4; flash mem $2; $1,$1, < $1
  - x100,000 < $45 domestic
  - China price-optimized < $30



Machine Learning

- We solve three degrees of freedom:
  - Aerodynamics and forced air
  - Voltage
  - Precision PM2.5 output based derived by ML



Data Syndication Repository

- Functional requirements
  - Upload and view unlimited data
  - Annotation of data with comments, photos
  - Active linking to all space-time views
  - Selective and private sharing
  - Embedding in all HTML5 regimes and mobile
  - Export with temporal and resolution windows
  - Map layer
  - Interactive animation
  - Mashable with all BodyTrack sources

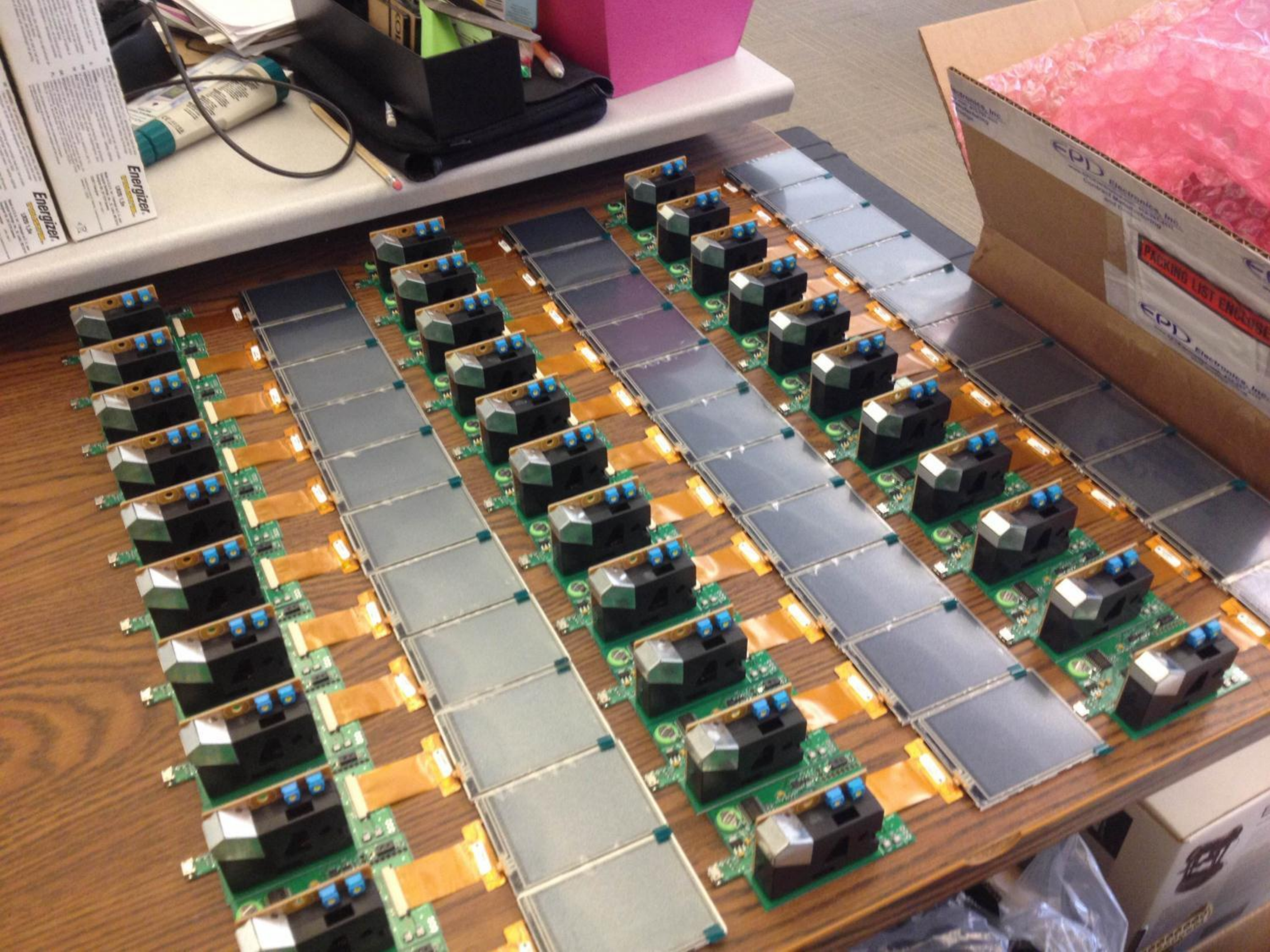
Existing Product Analysis

- We have tested and reviewed:
  - AirNow
  - Netatmo
  - Weather Underground
  - AirCasting
  - SafeCasting
  - Habitat Map
  - Fluxtream
  - Data.sparkfun.com
  - Xively
  - Cloudant
  - Mongo DB
  - CouchDB
  - PALO
  - SciDB
  - PostgreSQL

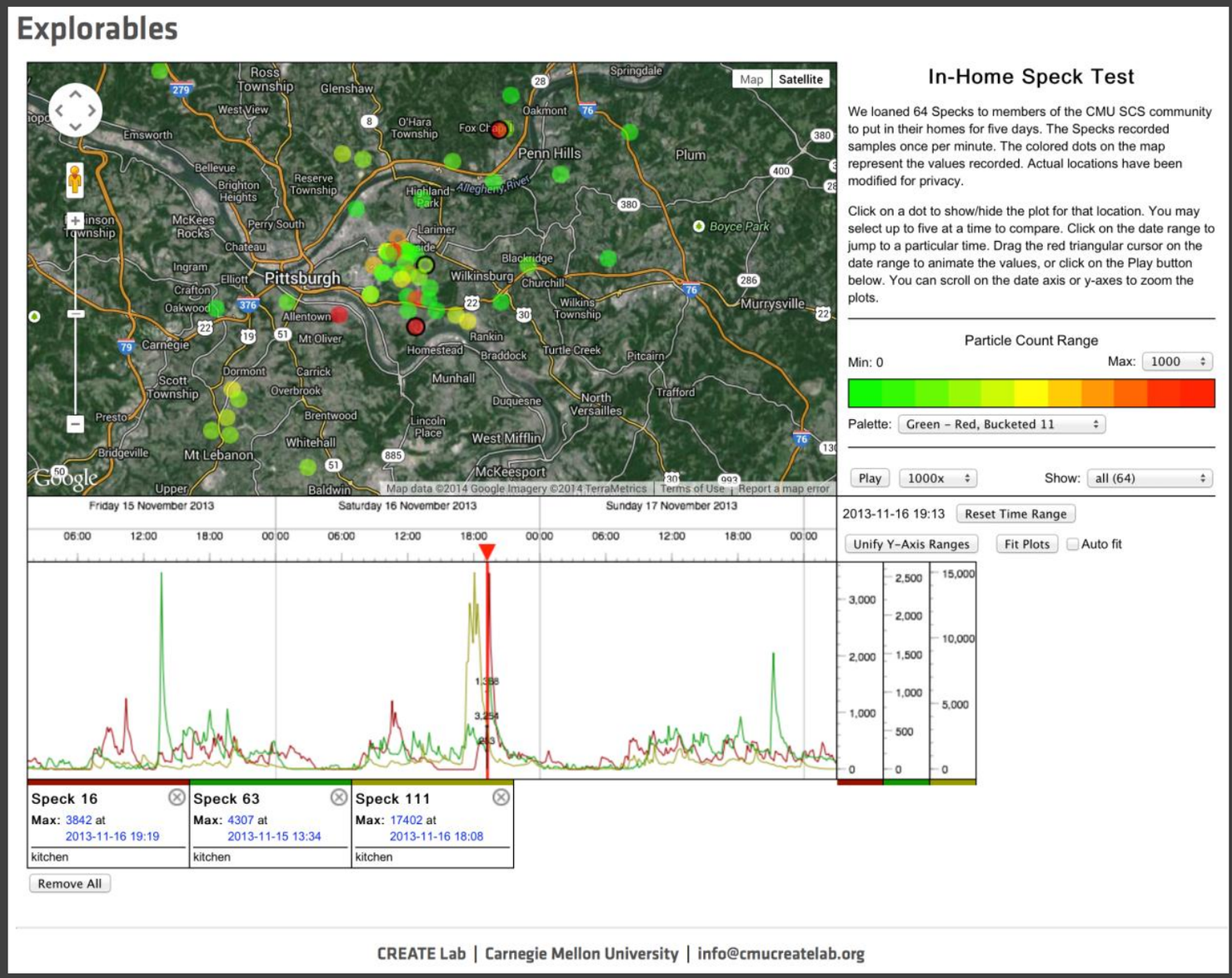
- **None provides ideal functionality, unfortunately**

Our Data Solution

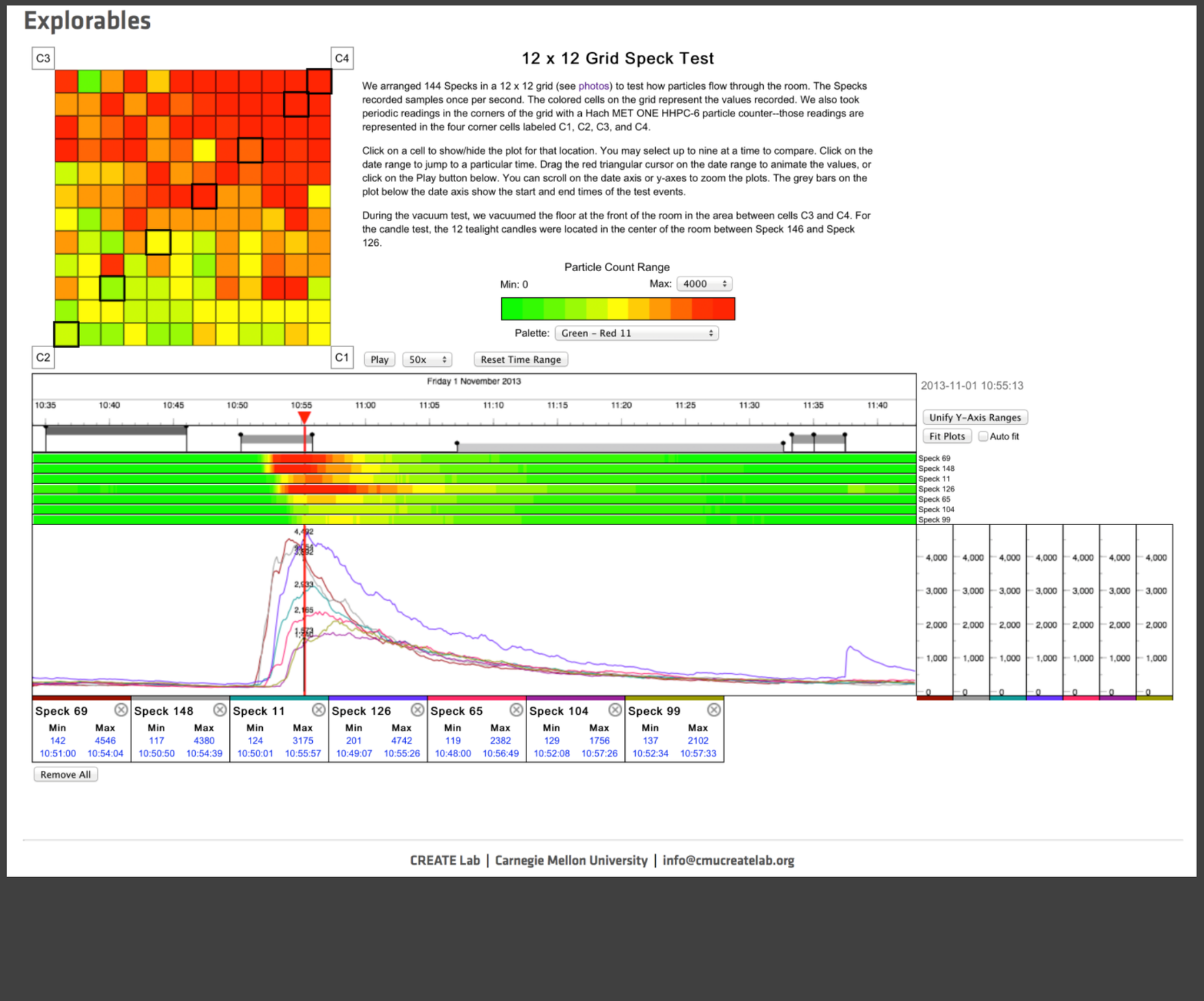
- Custom Node.js + Express server
- MySQL for all metadata
- Custom data store for unlimited size
- OAuth2 server authentication
- HTTPS everywhere
- Easy scale at billions of data points per device channel, immediately


Energizer
Energizer
PACKING LIST ENCLOSED

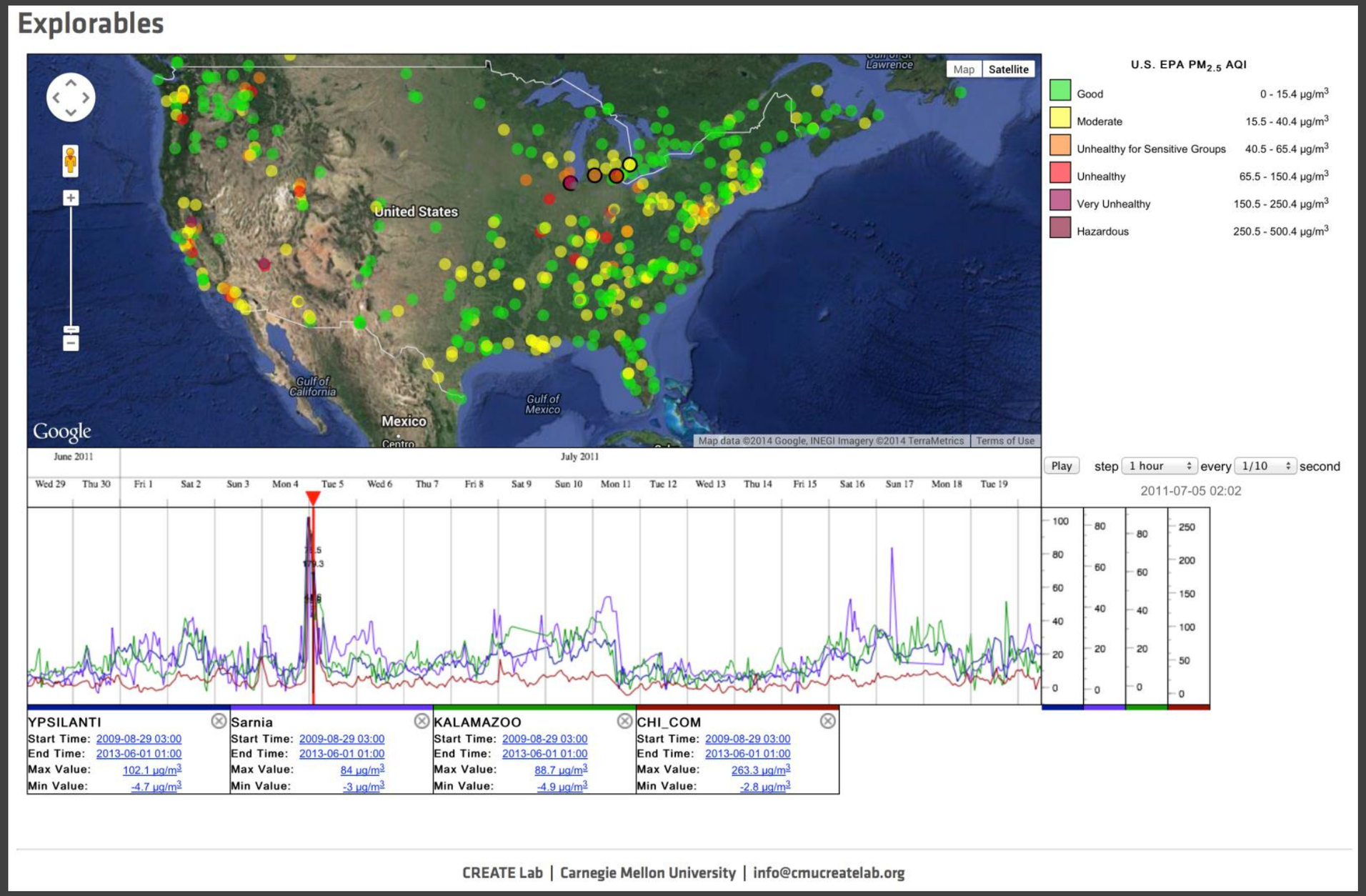
Visualization Samples using our Air Quality repository



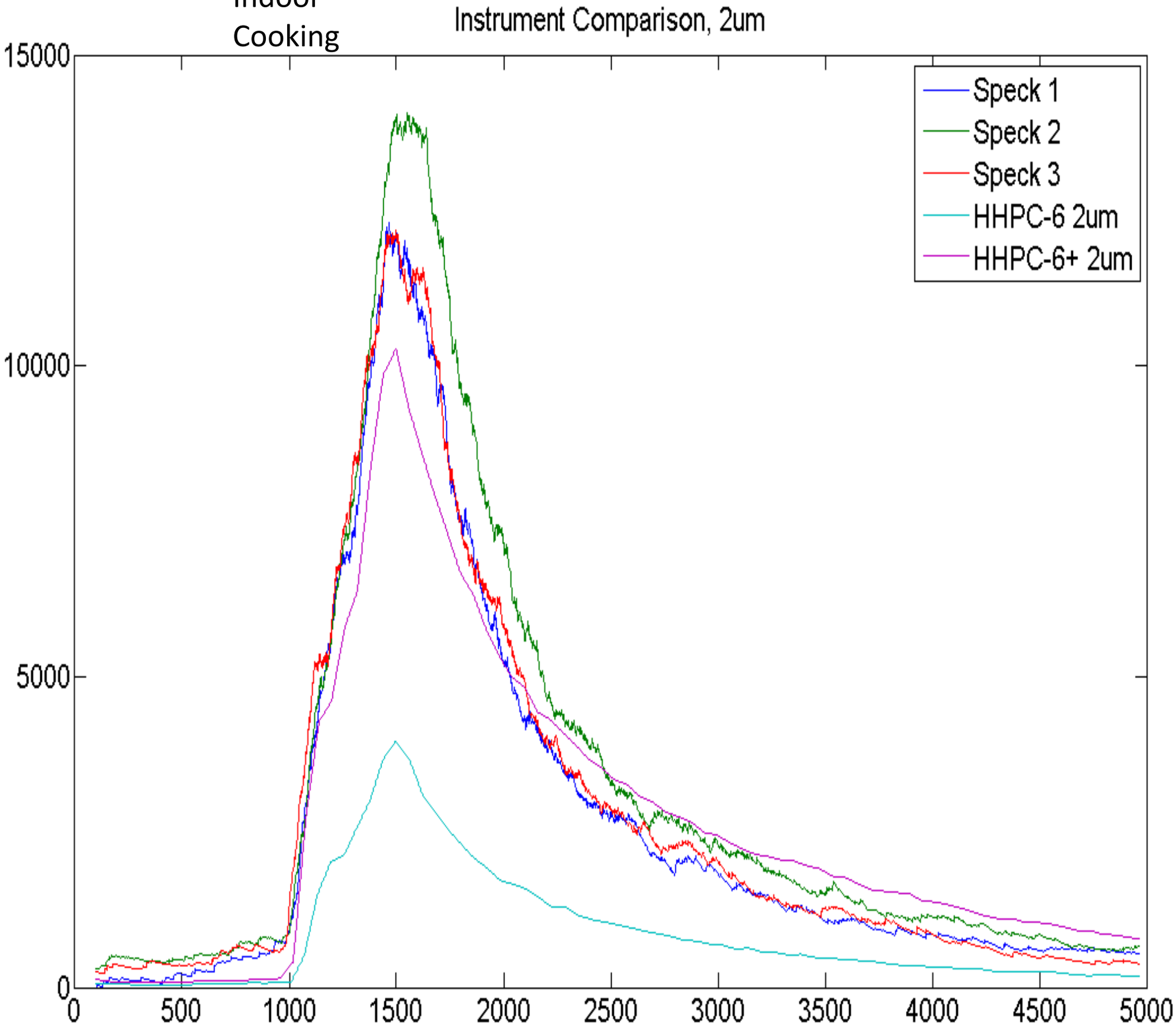
Visualization Samples



Visualization Samples



Indoor Cooking

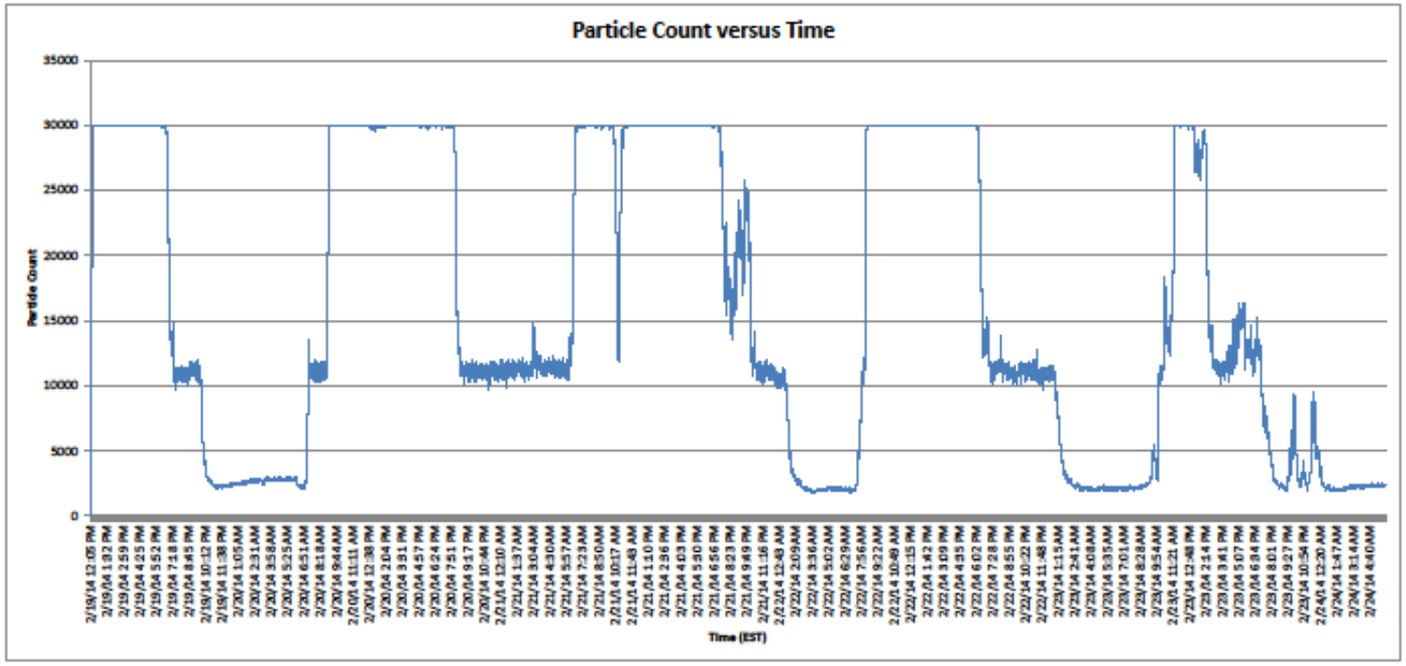


Indoor Cooking r^2 Values

		Specks			HHPC-6					HHPC-6+				
		Speck 1	Speck 2	Speck 3	.3um	.5um	1um	2um	5um	.3um	.5um	1um	2um	5um
Specks	Speck 1	1	0.987362	0.993636	0.158244	0.467073	0.924442	0.986689	0.888423	0.135631	0.417947	0.785144	0.963611	0.837748
	Speck 2	0.987362	1	0.980687	0.169643	0.533127	0.94508	0.9724	0.823798	0.137771	0.465185	0.840977	0.959146	0.76117
	Speck 3	0.993636	0.980687	1	0.14007	0.447569	0.909587	0.980447	0.89502	0.119966	0.397791	0.767833	0.956891	0.852869
HHPC-6	.3um	0.158244	0.169643	0.14007	1	0.64941	0.349996	0.207497	0.050446	0.974145	0.79976	0.447014	0.288995	0.040744
	.5um	0.467073	0.533127	0.447569	0.64941	1	0.722936	0.508535	0.1861	0.535591	0.964809	0.885504	0.611209	0.147489
	1um	0.924442	0.94508	0.909587	0.349996	0.722936	1	0.950106	0.70215	0.296839	0.678619	0.944562	0.979724	0.640184
	2um	0.986689	0.9724	0.980447	0.207497	0.508535	0.950106	1	0.878446	0.181373	0.472829	0.806847	0.984465	0.827515
	5um	0.888423	0.823798	0.89502	0.050446	0.1861	0.70215	0.878446	1	0.053579	0.17231	0.484569	0.803528	0.982561
HHPC-6+	.3um	0.135631	0.137771	0.119966	0.974145	0.535591	0.296839	0.181373	0.053579	1	0.694776	0.3682	0.254702	0.049259
	.5um	0.417947	0.465185	0.397791	0.79976	0.964809	0.678619	0.472829	0.17231	0.694776	1	0.819685	0.580059	0.14064
	1um	0.785144	0.840977	0.767833	0.447014	0.885504	0.944562	0.806847	0.484569	0.3682	0.819685	1	0.874768	0.42447
	2um	0.963611	0.959146	0.956891	0.288995	0.611209	0.979724	0.984465	0.803528	0.254702	0.580059	0.874768	1	0.760624
	5um	0.837748	0.76117	0.852869	0.040744	0.147489	0.640184	0.827515	0.982561	0.049259	0.14064	0.42447	0.760624	1

Example:
Sto-Rox School, Pittsburgh

Their Speck investigation showed massive periodic particulate spikes!



In Utah, a school borrowed Specks, measured pollution infiltration from idling cars, ran an education campaign, measured improvements indoors, and performed statistical correlation.

PM2.5 Reduction at Elementary School in Salt Lake County

Jamie S. Pluta MPH(s), Sara Shah MPH(s), and John Contreras PhD.

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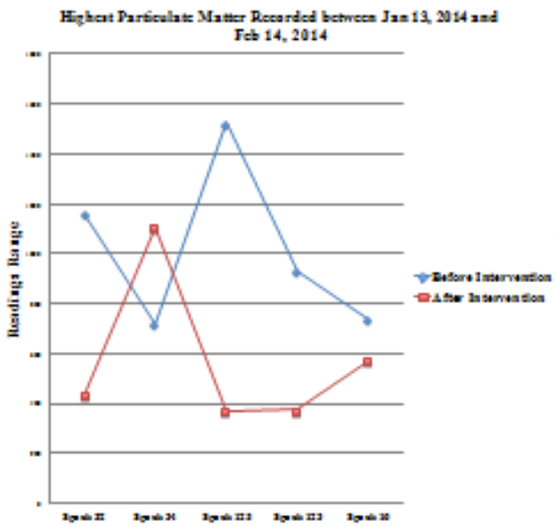
WESTMINSTER

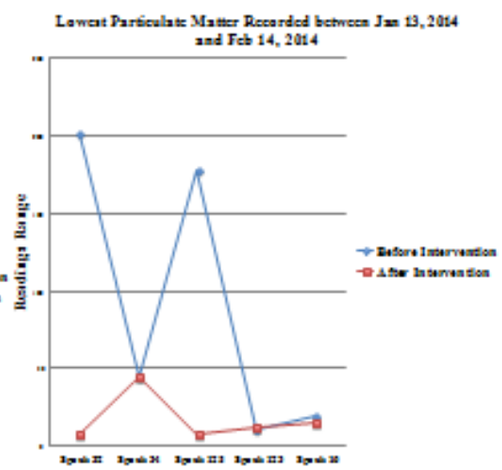
kground

e nation with the highest birth rate, and der the age of 18. In 2008, there were middle schools, and 113 high schools. nsidered bad for sensitive population chronic obstructive pulmonary disease other common respiratory diseases, indoors during recess as compared to evels of particulates and all of them are ess.

Sandy, Utah was selected as the pilot sts of grades kindergarten through five 18 teachers, two secretaries, a full time hree lunch staff, a librarian, and two h four teachers, and 24 students. Parent mbers and parent volunteers are also in

Graphical Data





Speck Monitor	Location	Before Intervention	After Intervention
32	Indoor	1163	433

Speck Monitor	Location	Before Intervention	After Intervention
32	Indoor	202	8

Results

The hypothesis is rejected therefore accepting the H_a that there is correlation between idling at elementary schools and air quality. Pri to the educational intervention there were between 186 and 237 ca seen idling at the school for longer than 10 seconds. Following t intervention there was between 173 and 216 cars seen turning off the ignitions rather than idling, resulting in an average of 92 perce reduction in idling. During the baseline data collection the lowest lev of PM2.5/liter of air measured by the SPECK monitors was 10, with mean of 91. After the intervention the lowest level was 8 with a me of 17.6. Before the intervention the highest was 1,526 with a mean 1016.8, after the intervention the highest level was 1106 with a me of 571. Using the students T-test for the low pre and post assessme resulted in $p = 0.0043$. The high pre and post test showed $p = 0.0001$.

Conclusion

Automobile idling during morning drop off and afternoon pickup tim directly affects the indoor and outdoor air quality at elementa schools. Shifting the community perceptions about air quality and t role that each citizen plays in improving the environment takes lon term environmental education efforts. Following the inoculati theory, it is critical to provide continued education not only to studer but to teachers, parents, and citizens. This study shows that people a willing and able to make behavior modifications when presented wi the facts and motivation to change. Continuing research should conducted about behavioral modification in regards to idling in warm temperatures, and when the threat of inversion wanes for the promoti of a healthier society.

Pilot in Pittsburgh

We have conducted Pittsburgh-wide surveys, and two pilots of 40-70 households in Pittsburgh, with Specks air quality sensors, to measure the degree of insight gained and empowerment achieved with respect to understanding and improving indoor air quality…

Real Investigations

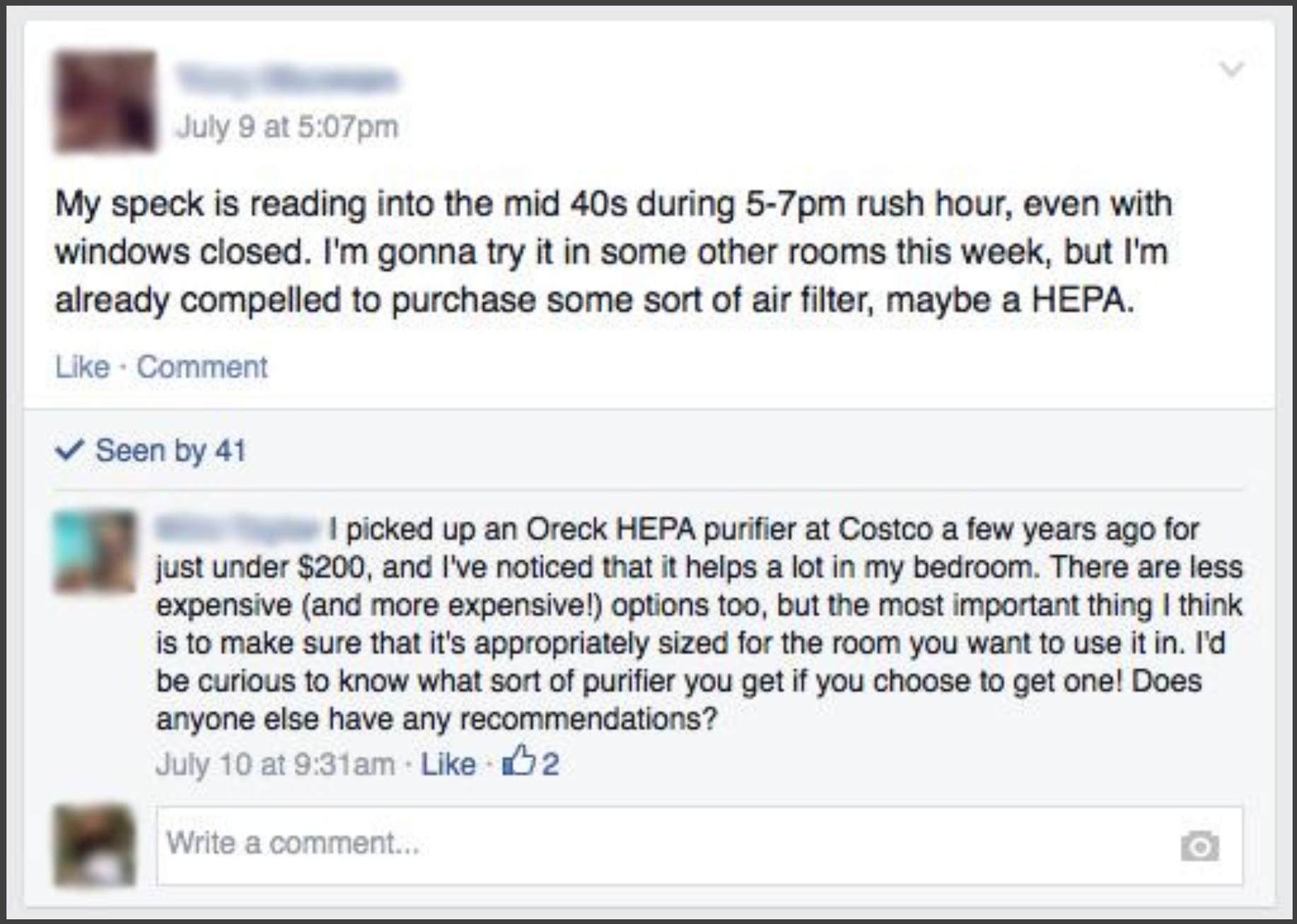
- "My husband and son have asthma and the Speck has been very informative about why their symptoms are worse at night. The readings in the bedrooms are much higher vs the front of the house. Appreciate the tips to improve the air quality and on the lookout for more. Will the Speck be available for purchase?"

- "I haven't had any readings above the mid teens. I have a high efficiency furnace filter. I run the furnace fan 24/7. I also use small 20 inch "box fans" in my family room and my bedroom. I put the same pleated high efficiency filter on the intake side of the fan and... presto... a budget air cleaner..."

- "Took my Speck to the studio yesterday to get some drawing done, got a Dangerous reading. Put on my dust mask and moved in the air filtering machine. Had no idea my studio is that polluted. Most of the higher readings happen when I open the windows. Three rooms can go from 10/12 to 40 just from an influx of late afternoon air. Had no idea Pittsburgh is that polluted."

Pilots Demonstrate Network Effect

Pilot results



[redacted]
July 9 at 5:07pm

My speck is reading into the mid 40s during 5-7pm rush hour, even with windows closed. I'm gonna try it in some other rooms this week, but I'm already compelled to purchase some sort of air filter, maybe a HEPA.

Like · Comment

✔ Seen by 41

[redacted] I picked up an Oreck HEPA purifier at Costco a few years ago for just under $200, and I've noticed that it helps a lot in my bedroom. There are less expensive (and more expensive!) options too, but the most important thing I think is to make sure that it's appropriately sized for the room you want to use it in. I'd be curious to know what sort of purifier you get if you choose to get one! Does anyone else have any recommendations?

July 10 at 9:31am · Like · 2

Write a comment...

Pilot results

Keywords from the respondents' survey comments: alert, notify, thresholds, action, suggestions, improve, useful

<u>If you had an air quality monitoring device in your home, what would you expect it to do for you?</u>

- ✓ ***Alert*** *me when certain* ***thresholds*** *are crossed.*
- ✓ ***Alert*** *me if quality needed* ***adjustment.***
- ✓ ***Alert*** *me at alarming* ***thresholds****.*
- ✓ ***Alert*** *me of unhealthy conditions.*
- ✓ ***Alert*** *me if air quality is unsafe*
- ✓ ***Alert*** *me to pollution spikes, as well as give me the long-term average.*
- ✓ *Monitor air quality and* ***notify*** *if not optimal.*
- ✓ ***Notify*** *me when outside of* ***a safe range****, then maybe do something about it, or* ***suggest what to do****.*
- ✓ *Show readings, benchmark information to* ***compare*** *readings, and advice on* ***how to fix problems.***
- ✓ ***Alert*** *me when there were high/concerning levels so I could* ***react****.*
- ✓ ***Alert*** *me to serious pollution levels, educate me about general levels.*
- ✓ *At minimum,* ***alert*** *me to hazardous conditions in my home. Ideally, I would be able to customize the device to* ***alert me about changes in the air quality that could affect my particular ailments.***
- ✓ *I would want to be* ***alerted*** *to changes in air quality e.g. allergen levels that go over a safe threshold (and I would want it to know what the safe threshold is). It would be nice if it* ***connected to an air purifier*** *that would kick on as needed.*
- ✓ ***Advise*** *me of health/comfort concerns.*
- ✓ ***Let me know when I need to take action.***

Speck indeed aided users to take certain actions to improve the indoor air quality

- ✓ *Previous to using the Speck, we had been having some boiler issues... We ended up replacing the motor on our boiler – the Speck results were certainly a factor in us realizing we had to get the issue taken care of.*

- ✓ *The big surprise was sweeping. Wow!*

- ✓ *[Started to] turn on the vent fan more often.*

- ✓ *[Started to] using the hood more over the stove.*

Upcoming Plans & Networking

January: Davos WEF

March: SXSW Austin

Acknowledgments

Randy Sargent: Visualization, GigaPan Time Machine

CREATE Lab, PI's and research staff
www.cmucreatelab.org

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