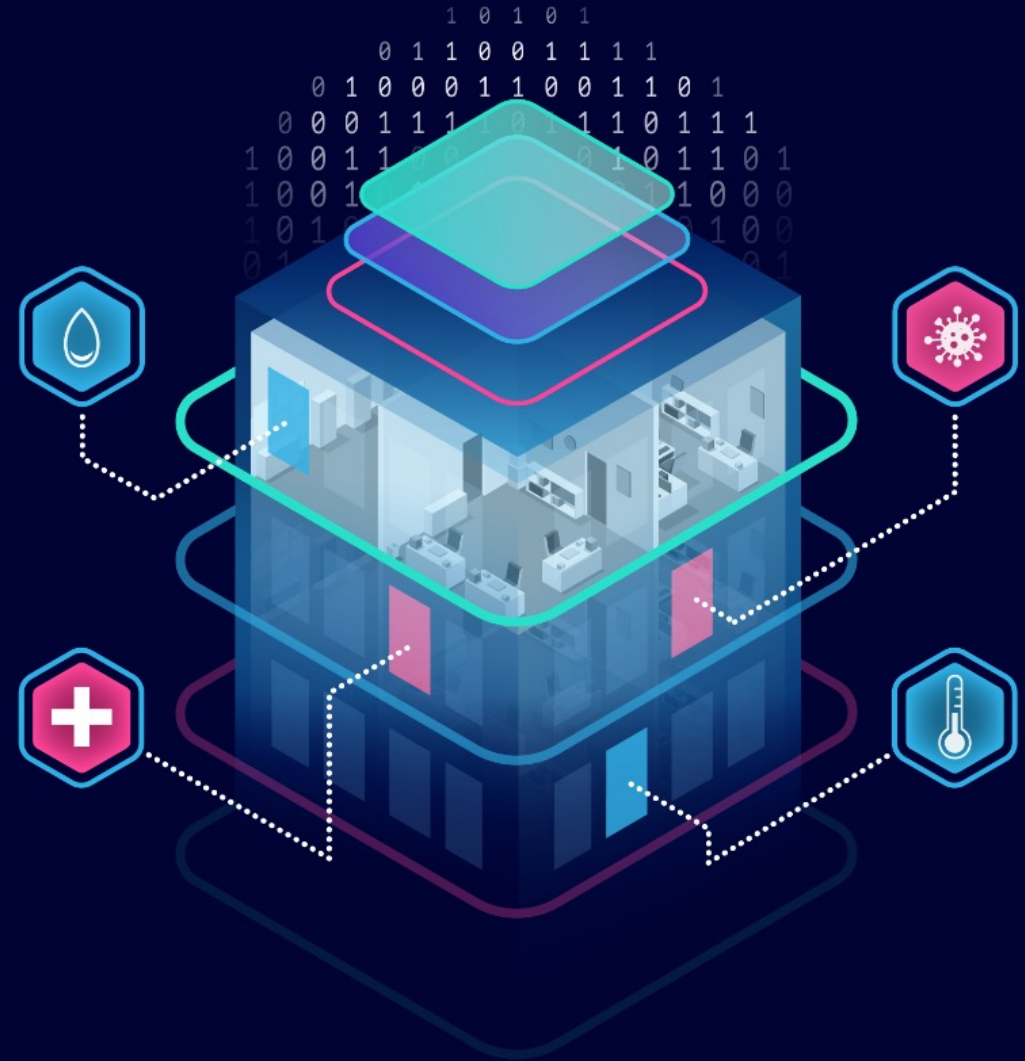


BREATHE

Building Resilient
Environments for Air
and Total HEalth

Matchmaking Webinar 2



Housekeeping Items

- Please remain on mute. If you are a panelist with an approved lightning talk, you will be invited to unmute later in the presentation.
- Please enter any technical questions in the chat.
- Please check your Audio Settings if you are having difficulties hearing us.

Agenda

- Introduction to ARPA-H and BREATHE
- Lightning Talks
- Conclusion and Next Steps



ARPA-H Mission

Accelerate better
health outcomes
for everyone.



Program Launch!

Building Resilient Environments for Air and Total HEalth (BREATHE)

Vision: A future with healthy indoor air for everyone.

Technology focus areas:

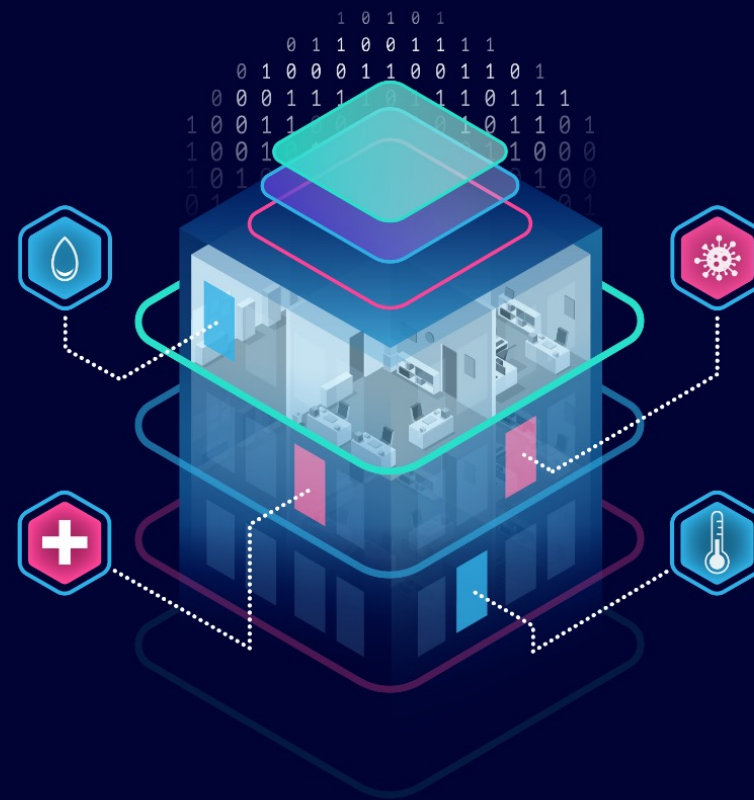
- Indoor Air Biosensors (TA1)
- Respiratory Risk Assessment Software (TA2)
- Healthy Building Controls and System Integration (TA3)
- Real-world efficacy trial (TA1 + TA2 + TA3)

How to apply

- Submit solution summary (encouraged)
- Submit full proposal
- **Visit arpa-h.gov** for more information about BREATHE and applying to the PS or email: **BREATHE@arpa-h.gov**

Key Dates (note: dates have been updated)

- **Solution summary due on June 21st, 2024**
- **Full proposals due on August 26th, 2024**



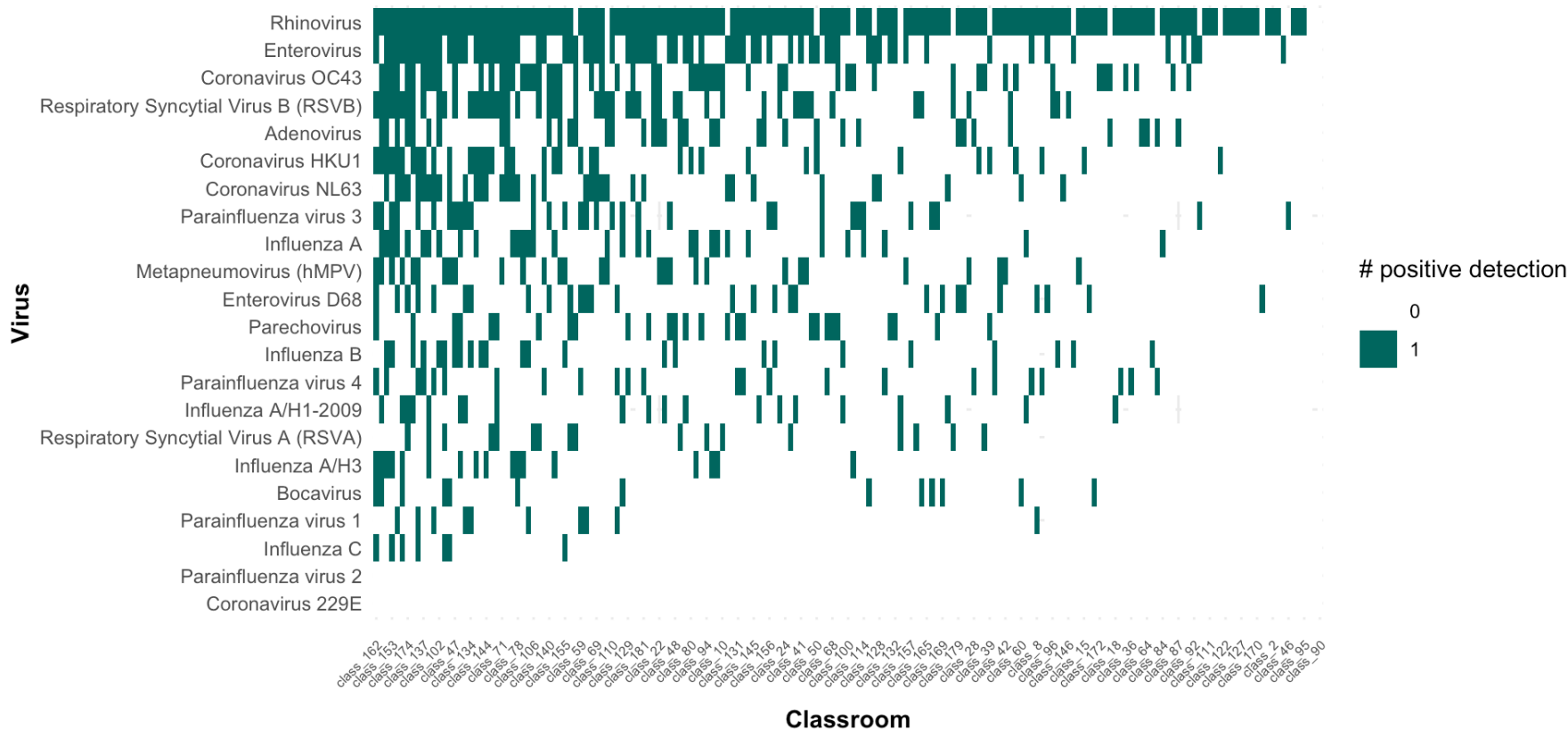


Lightning Talks

Tips for Presenters

- The BREATHE team will share your slide on the screen during your presentation.
- You have three (3) minutes to give your talk and a member of the BREATHE team will say “One minute left!” when you have one (1) minute left and “Out of time!” when your time is over.
- We ask that you keep your talk to a maximum of three (3) minutes to ensure a timely webinar.

ARPA-H BREATHE lighting talk: Respiratory virus exposure in bioaerosols collected from elementary schools



Ongoing school-based studies

- ClinicalTrials.gov NCT02291302
- ClinicalTrials.gov NCT05953233

ddPCR assays for multiplexed detection of respiratory viral pathogens in classroom bioaerosols

Looking for teaming partner focused on schools

Contact:

Peggy Lai

PLAI@mgh.harvard.edu

Lai-lab.com

GSA's Portfolio - Where do we manage the indoor air?

- 360 Million rentable square feet
 - 190M SF in 1,685 federally-owned assets
 - 170M SF in 6,590 leased assets
- Housing 1.1 Million+ federal employees
- 168 Smart Buildings on GSALink (~50% of owned SF)
- Active Research Programs:
 - [GSA's Center for Emerging Building Technologies / Green Proving Ground](#)
 - [Office of Federal High-Performance Green Buildings - Wellbuilt for Wellbeing](#)
 - *New in Fall 2024: National Academies of Science, Health in Buildings Roundtable*

Facility Type	<i>Total SF (Millions)</i>
Office	103.6
Courthouse	64.3
Warehouse	7.1
Land Port of Entry	4.8
Laboratory	1.7
Public Facing Facility	0.9
Child Care Center*	0.2
Parking	0.2
Other	3.9

ARPA-H Teaming/Matching Summary



Team Associations

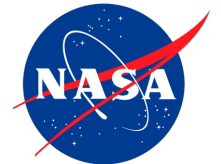
NC STATE UNIVERSITY

P PURDUE
UNIVERSITY.

 University of Colorado

Yale

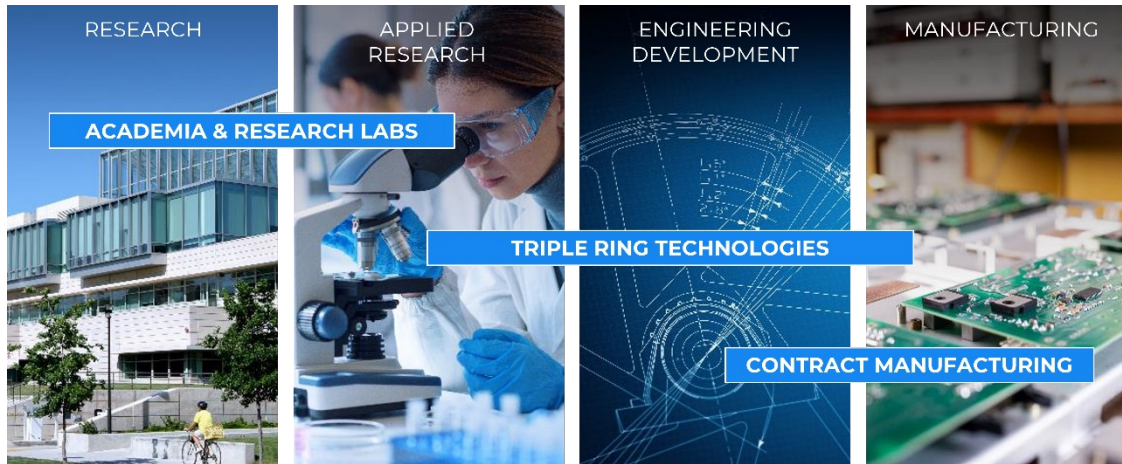
ZeteoTech



- XCMR Inc. (www.xcmr.co) –
Ken Kelley, Chairman & cofounder (ken@xcmr.co), Rick Rasansky, CEO & cofounder (r@xcmr.co)
- Industry recognized multidisciplinary science and business team skilled in
 - near-field infection protection devices as biosafety barrier for close contact environments
 - advanced photochemistry reactor theory,
 - ultraviolet (UV) radiation and disinfection processes,
 - fluence rate fields,
 - aerosol transmission of infectious diseases,
 - CFD modeling/simulation,
 - IAQ risk assessment,
 - biological mass spectrometry sensors,
 - IoT and software applications
- Seeking potential teammate(s) skilled in
 - Facility Control Systems (TA3)
 - Complementary Indoor air biosensor technology (TA1)
 - Complimentary data scientists for (TA2)

ARPA-H BREATHE Lightning Talk

We Bridge the Technology Gap



Company Overview

- Founded in 2005 with offices in Silicon Valley & Boston
- Staff of over 100, 25% PhDs
- Certifications include ISO 13485 and others
- Relevant capabilities
 - Feasibility, simulations & modeling, algorithms
 - Design/build/integrate/test/validate diagnostic and therapeutic technologies and platforms
 - Design for scale-up and manufacturing

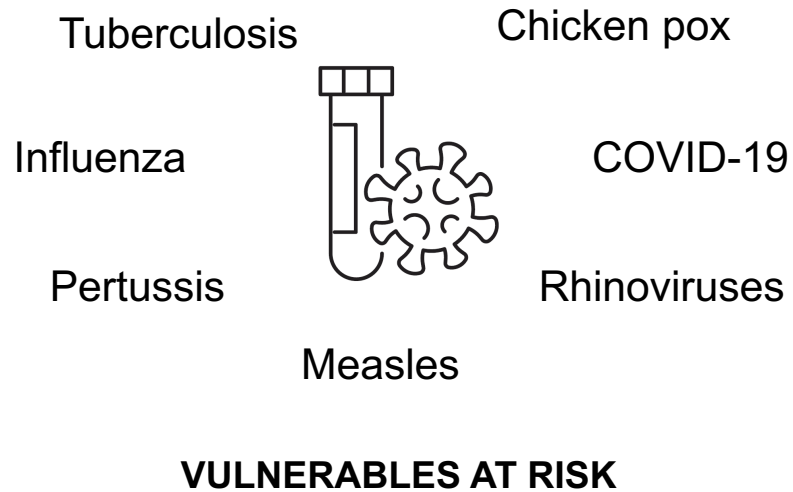
Examples of Our Work



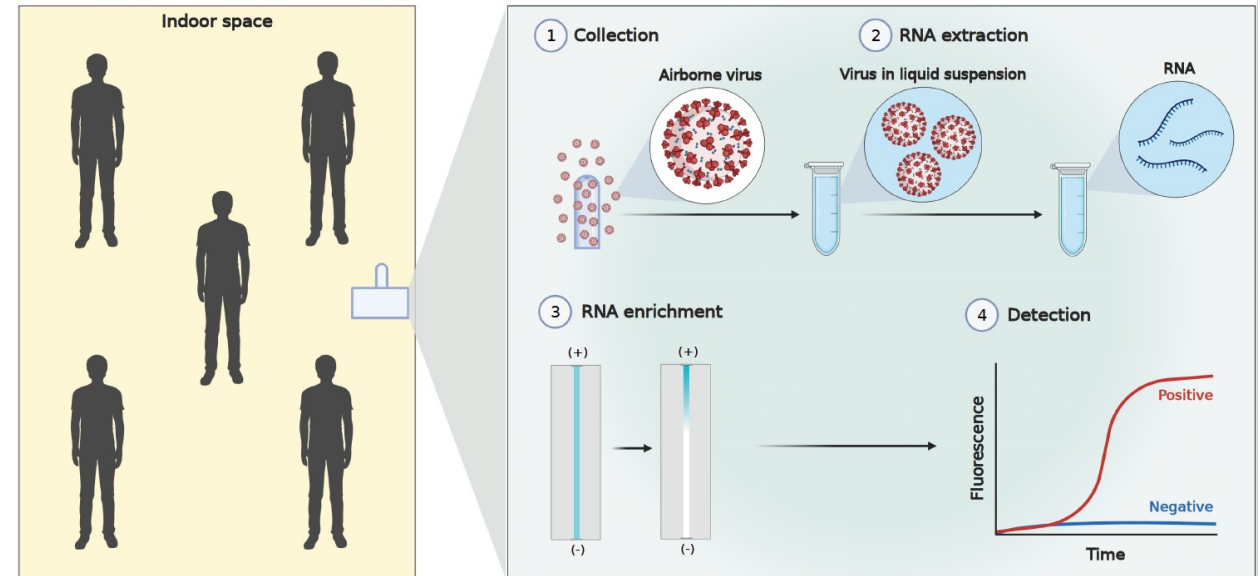
Advancing Indoor Pathogen Detection with BREATHE

Team Del Vecchio, Massachusetts Institute of Technology

COVID-19 NOT THE ONLY THREAT



OUR APPROACH



WHAT WE ARE LOOKING FOR

Current performance*:

sensitivity: 5genome copies/L of air

Timeliness: ~1 hr

- Connections and contacts in healthcare
- Entities with product development expertise
- Entities with engineering and manufacturing capabilities

*Du, Bruno, Overholt, Palacios et al. Biosensors and Bioelectronics: X (2024): 100488.
<https://deshpande.mit.edu/projects/system-for-on-site-detection-of-virus-loaded-aerosol/>

Biosensing Platforms for Volatile Organic Compound Biomarkers: Towards Noninvasive Health Monitoring at the Point-of-Need

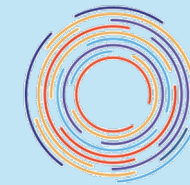
Mangilal Agarwal*, Mark Woollam, and Dipak Maity

Integrated Nanosystems Development Institute, Indiana University

*agarwal@iupui.edu



INDIANA UNIVERSITY



AGARWAL LAB
INTEGRATED
NANOMATERIALS



INTEGRATED
NANOSYSTEMS
DEVELOPMENT INSTITUTE
INDIANA UNIVERSITY-PURDUE UNIVERSITY
Indianapolis



Canines smell volatile organic compounds (VOCs) noninvasively to detect medical conditions



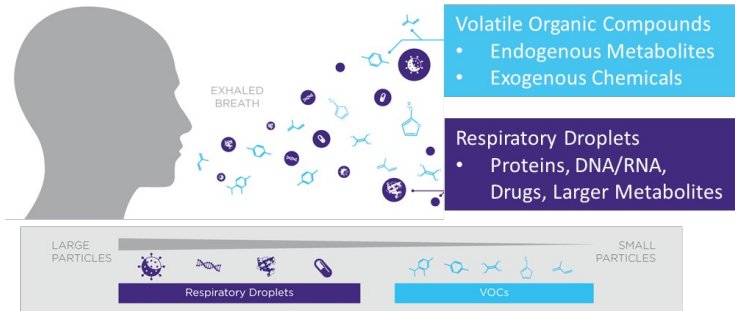
VOCs are byproducts of metabolic pathways altered by different diseases



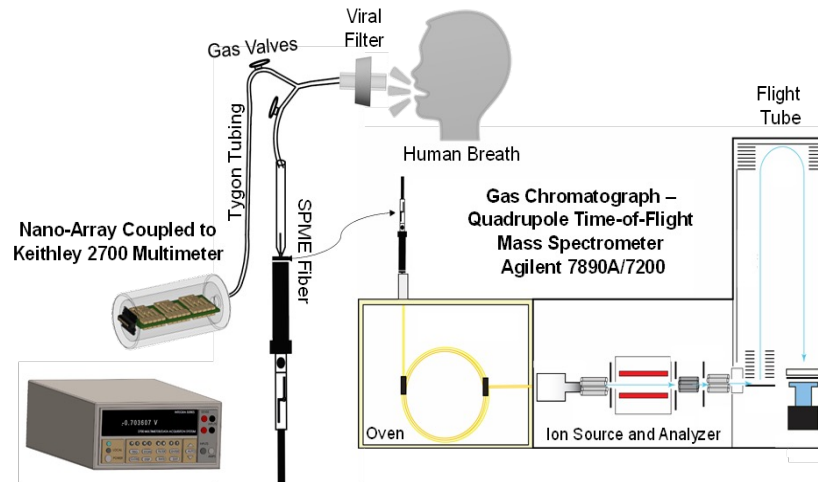
Most common sample types analyzed include breath, urine and sweat



Breath-based diagnostics gaining attention because it is limitless and noninvasive

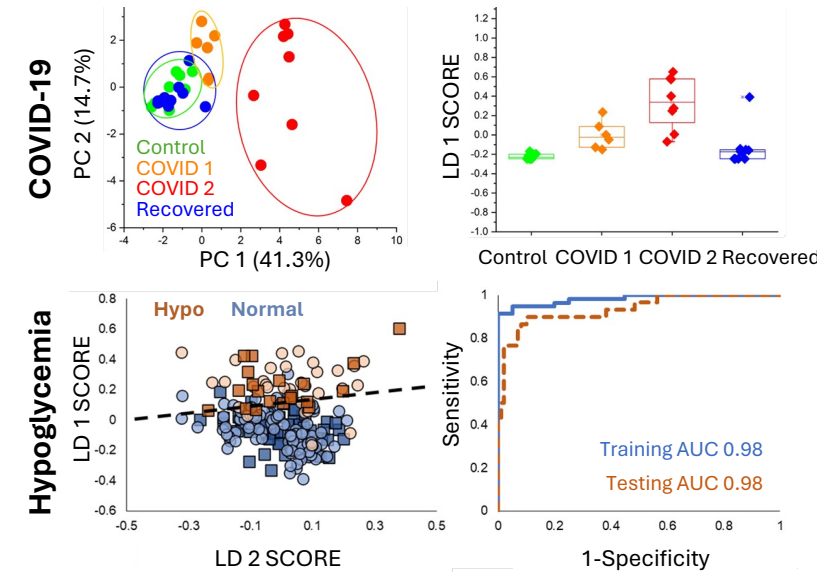


Analytical Methods for VOC Biomarker Detection

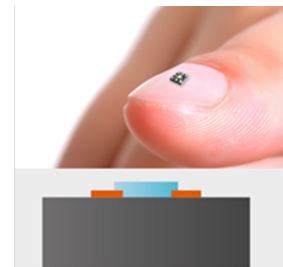
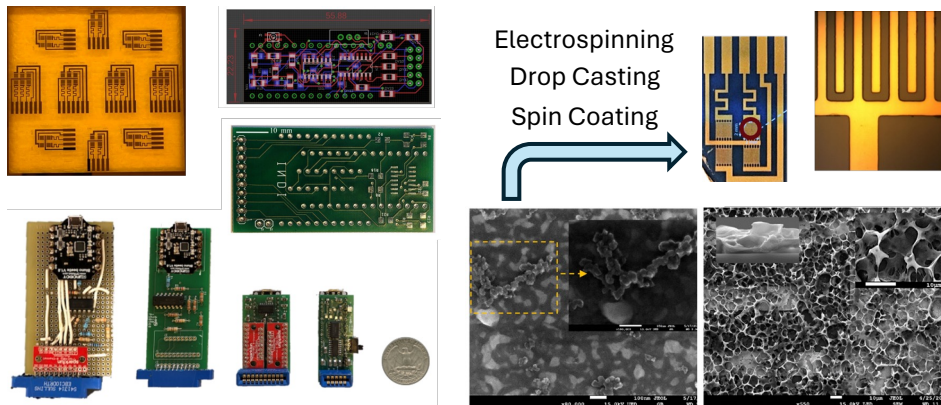


Wearable Breath-based Prototype (Industry Collaboration)

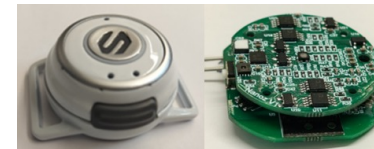
In-House GC-MS VOC Databases



Targeted Development of Breath-based Biosensors



Nano Tech layer (Patent)
Transducer circuit (Patent)
Support layer



NANOZ
SCOSCHE
THE NECESSARY ACCESSORY

Future Vision for ARPA-H BREATHE

1. Passive Monitoring of VOCs Emitted from Bacteria + Fungi
2. Breath-based Monitoring of Host Biomarkers (Viral)
 - a) Passive Monitoring of Indoor Spaces and Groups
 - b) Active Monitoring of Individuals by Breathalyzer



<https://www.epa.gov/indoor-air-quality-iaq/air-sensor-technology-and-indoor-air-quality>

<https://www.news-medical.net/health/Could-a-breathalyzer-detect-cancer.aspx>

Organization: Centers for Disease Control and Prevention (CDC) - National Institute for Occupational Safety and Health (NIOSH), Respiratory Health Division

Technical Area 3: Leverage protective and responsive building interventions to reduce bioaerosol exposure risk at optimal costs

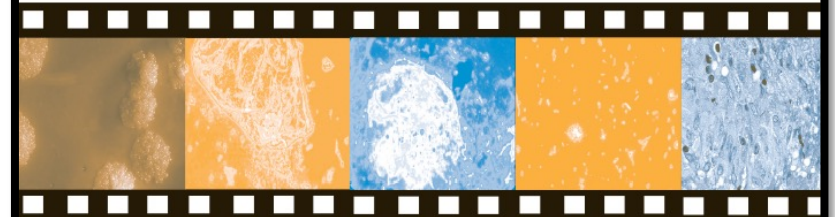
What We Do: Multidisciplinary research to identify work-related respiratory hazards, assess workplace exposures, characterize health risks, and develop and disseminate effective interventions

APRA-H Focus: Germicidal ultraviolet (GUV) as an intervention to reduce indoor transmission of respiratory infection in workplaces

Teaming: To complement our expertise in GUV, ventilation, human health risk assessment, translational science, and clinical research, we seek partners with expertise in indoor air biosensors (TA1) and respiratory risk assessment software (TA2).

Contact: Lew Radonovich: mto5@cdc.gov

*Environmental Control for Tuberculosis:
Basic Upper-Room Ultraviolet
Germicidal Irradiation Guidelines
for Healthcare Settings*



Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

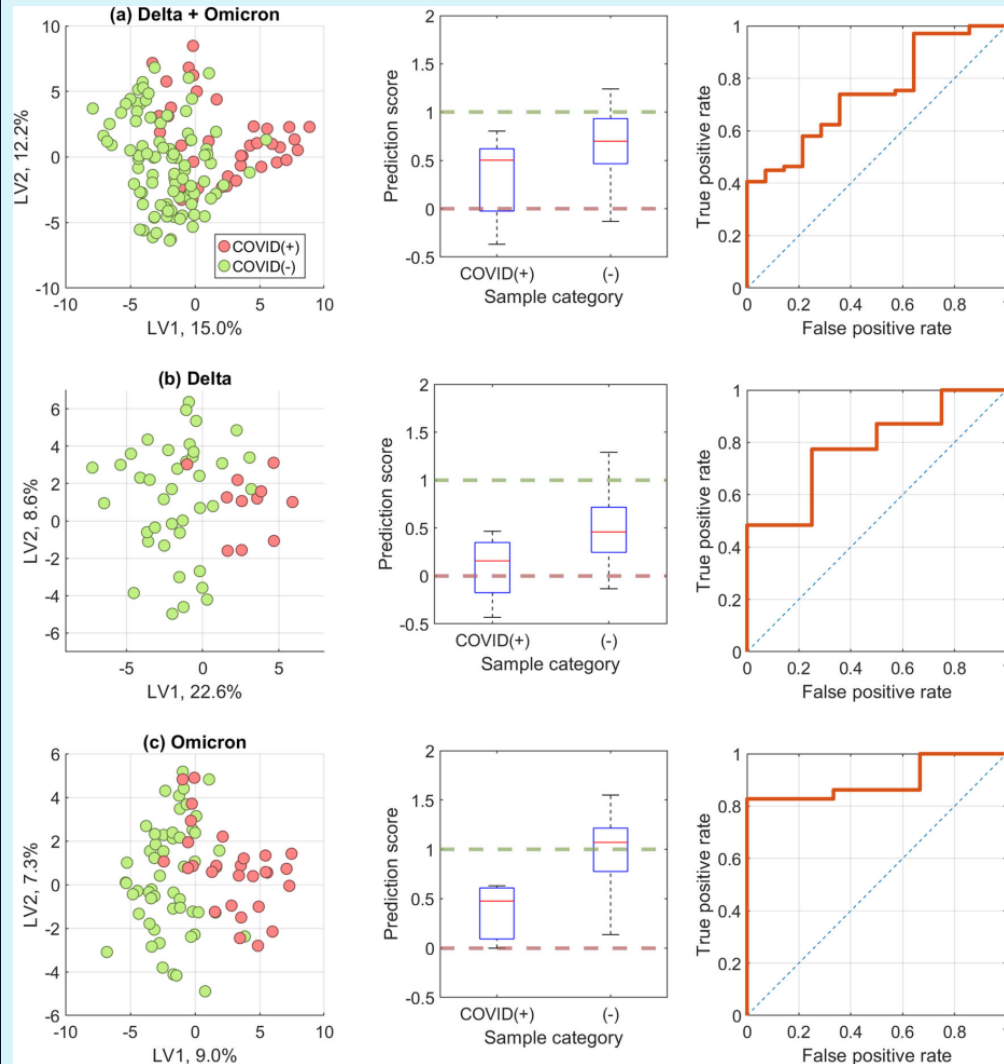


NIOSH

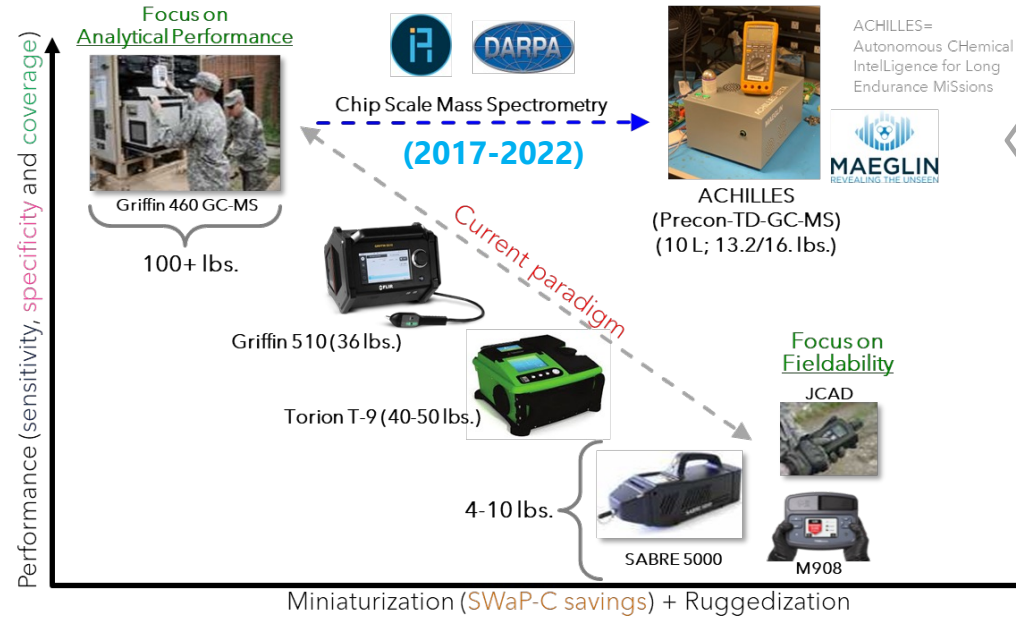
Who cares about breath VOC!

Selective Detection of SARS-Cov-2 **Variants** from Exhaled VOCs

McCartney, et al., Commun Med (2022) 2:158



Disrupting the Field-Forward Trace Chemical Detection Paradigm



Many Firsts!

- Only performer to detect and identify all 36 chemicals and even the true unknown* in an independent government testing
- Mass spec on "demand"!
- Mass spec on a plane!
- Mass spec in subway system!

*DeWitt K. "Advancements in compact gas collection and analysis from IARPA's MAEGLIN program." CBRNE Sensing XXI. Vol. 11416. International Society for Optics and Photonics, 2020.

Detect-ION is adapting ACHILLES for **PoC BREATH DIAGNOSTICS** & applying to infectious diseases (viral and bacterial), lung cancer, and a Malaria/TB pilot.



TA-I approach

Robust "workhorse" VOC analysis

Cueing approach for multiplexing bio sensors

Inspect each subject in the infected room



ARPA-H (BREATHE)

Strategic Goals:

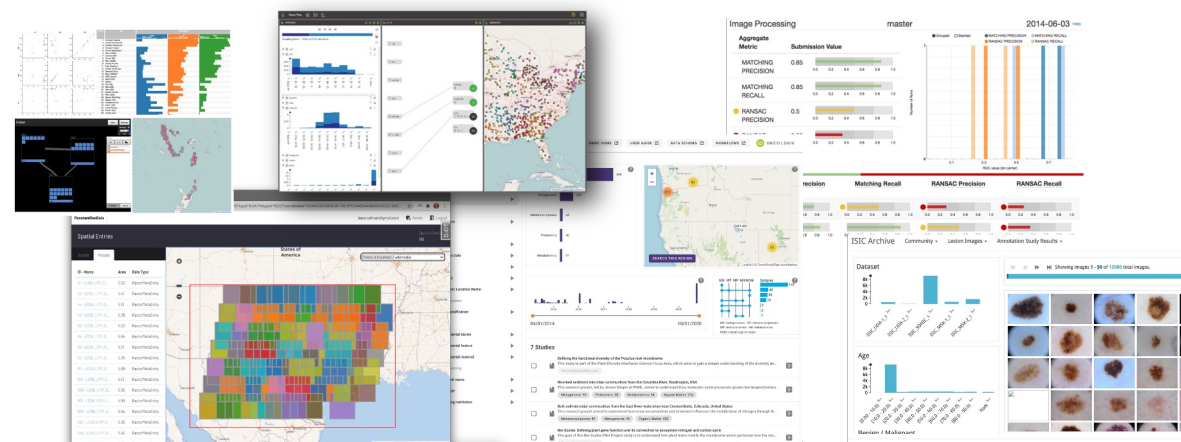
- We are seeking partners across all TAs
- Open to priming and/or sub-ing
- Open to cost-share scenarios

Point of Contacts

- Ashish.Chaudhary@detect-ion.com (Founder/CTO/CEO)
- Gregory.Vasquez@detect-ion.com (Principal Scientist)

We are a good fit for a research-heavy team that needs expertise in building **interactive, visualization-centric applications** for domain scientists and building system operators (visualizations, UI/UX)

Scientific dashboards, visualization, evaluation and validation, UX



GreenVision Systems, Ltd. - Automated Near-Real Time Bioaerosol Monitor for TA1



GreenVision Systems®

GVS HyperEye-AP [BDC] Features and Benefits

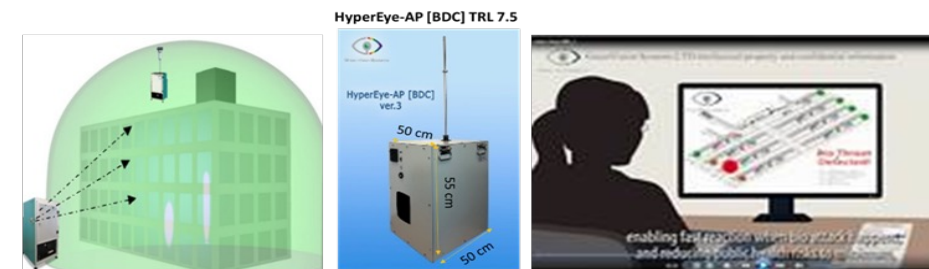
- ✓ Can detect viruses, bacteria, fungi, specific allergens, and atmospheric particulates.
- ✓ Results reported in 10 min following sample collection.
- ✓ Variable sampling cycle, as low as ½ hr.
- ✓ Automated (continuous) sampling and analysis **with anomaly detection capabilities**.
- ✓ The system has high adaptability: characteristics can be adjusted to fit rapidly changing conditions and future treats.
- ✓ High sensitivity (detection of down to few bio-aerosols per liter).
- ✓ Very low FAR and with high PoD (up to 99% @ concentration).
- ✓ Easy to use and low cost.
- ✓ Includes database, report generation, system-control, data links, MMI, recording, self-testing procedure.
- ✓ ISO-13485, ISO-9002 and Israeli FDA Certificated.
- ✓ Our system is at TRL8.
- ✓ We're focused on TA1 and looking to partner with other groups.
- ✓ Contact: Danny Moshe danny@greenvs.com

Bio Threat Operational Procedures

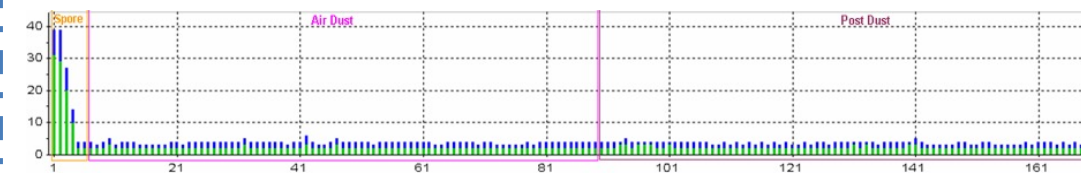
Air Sensing at sites;
Prevention Delay

Detection

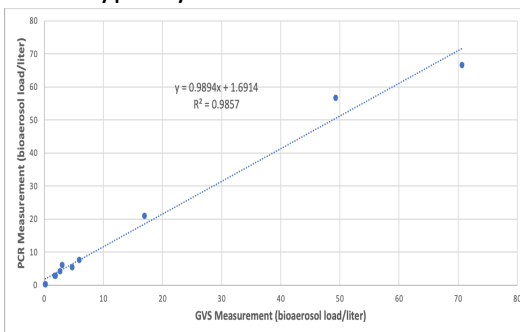
Identification and
quantification



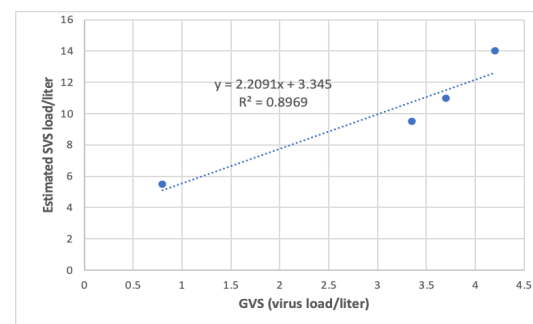
Example: Monitoring of PM and mixed concentrations of bio-spores (between 500 and 10/liter).



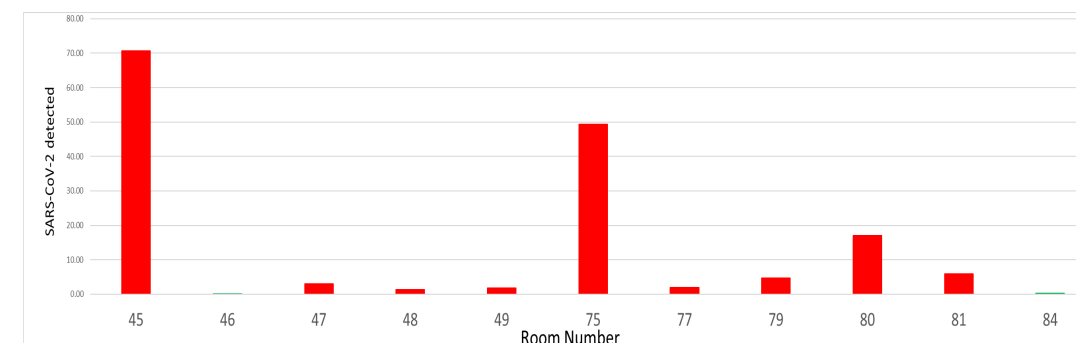
Example: Comparison of SARS-CoV-2 levels in RAMBAM Hospital measured using the GVS HyperEye vs. PCR.



Example: Indoor sensing SVS viruses.



Example: Indoor air monitoring of SARS-CoV-2. Red bars are patient rooms, green bars are laboratory spaces. (Note lower concentrations observed in labs.)



This portfolio review aims at showcasing the CRBT's capability to contribute to deliver critical aspects of **TA1** and identify complementary collaborators to address **TA2** and **TA3** requirements and specific aspects of **TA1** (e.g. multiplex assays)

Bioaerosol Collection Systems



Handheld electrostatic precipitator

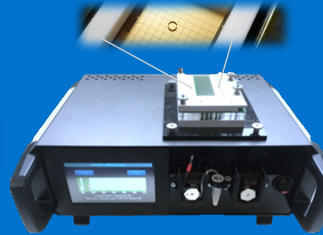


Cyclonic collection systems



Filter collection systems

Aerosol Sample Recovery

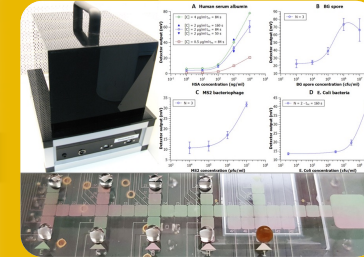


Electrowetting on dielectric in-droplet recovery system

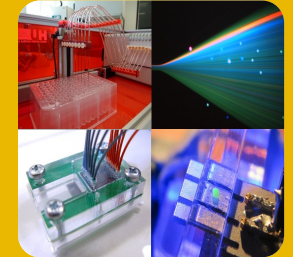


Foam filter extraction system

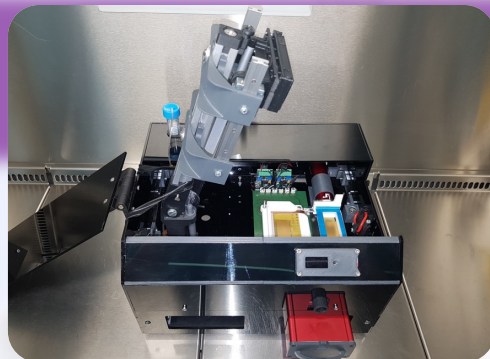
Detection/Analysis



Digital microfluidics (DMF) for detection of pathogens



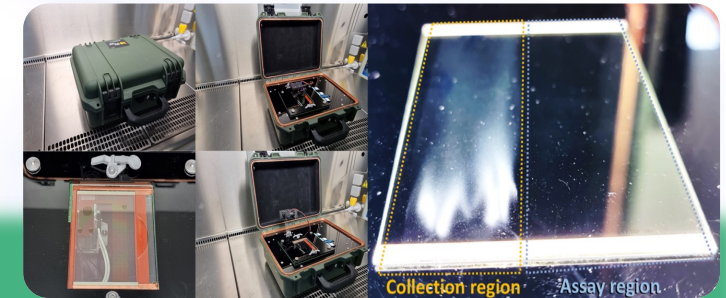
Microfluidics for sample prep. and analysis



Aerosol to droplet sampling integrated system

Integrated collection to recovery

“Dry samples” detection (integrated recovery)



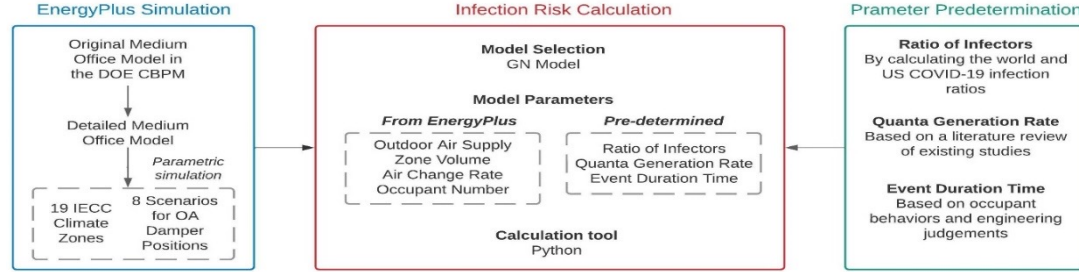
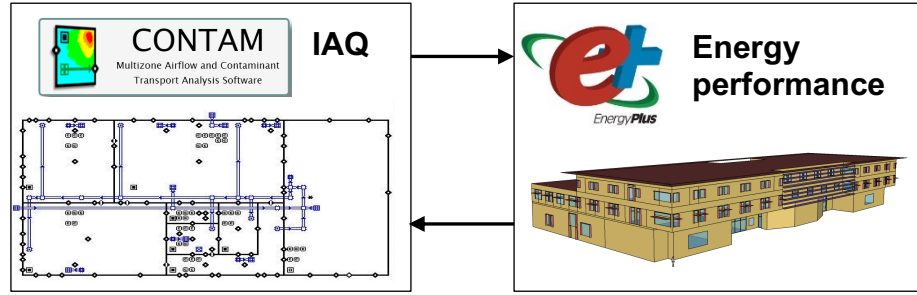
DMF-LAMP unit for “dry samples” detection



7-days automated crop monitoring system – “Spore Sentry”

Automated collection to detection

Theme 1: Building Energy and IAQ Performance Assessment

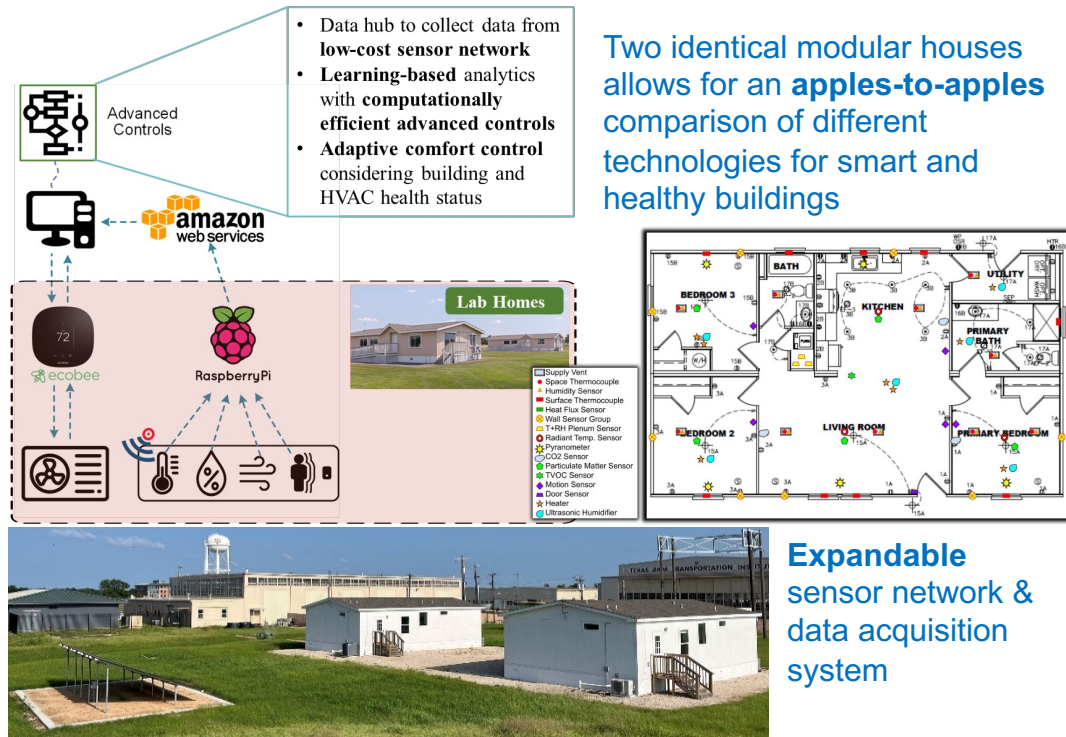


Quantification of How Smart Ventilation Influences the Airborne Infection Risk of COVID-19 and HVAC Energy Consumption

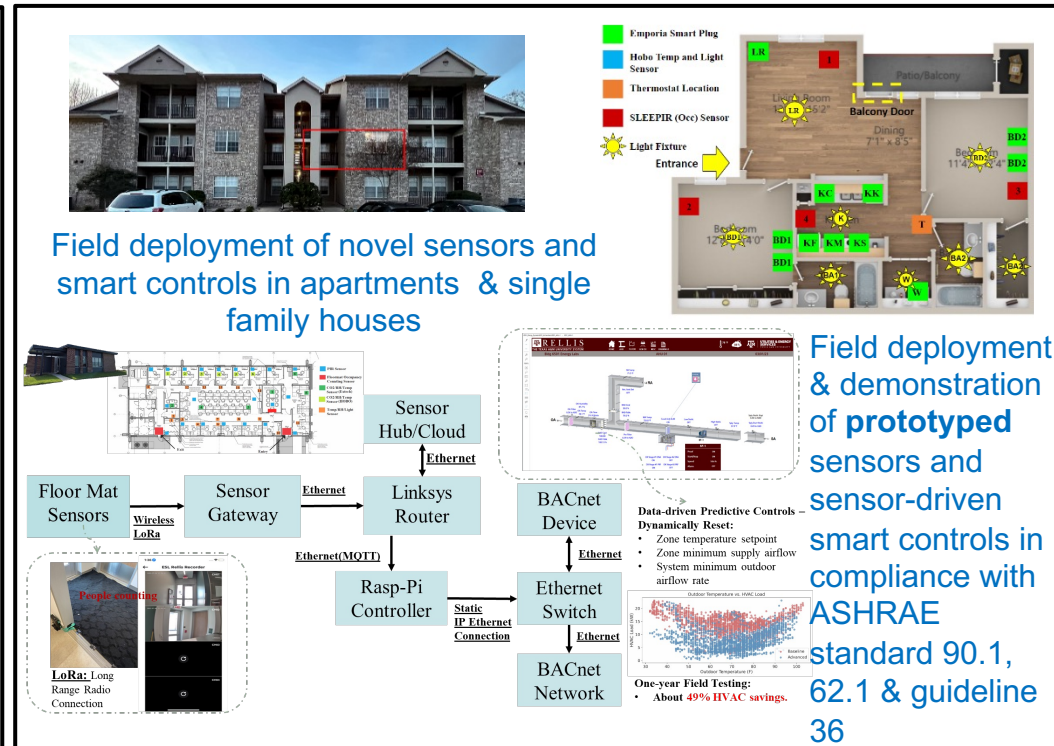
ARPA-H BREATHE program related expertise:

- Implementable intervention strategies though filtering, smart ventilation, UV, etc.
- Laboratory & whole building level testing
- Energy and IAQ performance modeling and assessment
- Advanced and implementable HVAC controls and system integration

Theme 2: Controlled Laboratory Testing of Building Energy Performance and IAQ



Theme 3: Field Demonstration of Building Energy and Control Systems



Contact:

- Dr. Zheng O'Neill ZONeill@tamu.edu
- Dr. Zhiyao Yang Z.Yang@tamu.edu

<https://hvac.engr.tamu.edu/>

Next Steps

**Find information about Teaming,
FAQs, Key Dates, and More!**

BREATHE Program Page:



**Mark your calendar with these
Key Dates!**

- June 21, 2024:
Solution Summaries Due
- August 26, 2024:
Full Proposals Due



We are a leading biomedical contract research organisation specialising in the field of **aerobiology**.

Our **state-of-the-art laboratories** (virus, bacteria, mold and allergen) combined with multiple climate-controlled chambers allow us to offer our clients a unique service.

Our **environmental test chambers** are suitable to assess various technologies capable of monitoring and managing indoor air, creating and **quantifying specific airborne bioaerosols** and **assessing indoor air quality exposure risk**.

We can assess and verify the capability of various **tools and technologies** purporting to contribute to healthy indoor air including those **bioaerosols** and **surface infectious agents** that contribute to chronic disease and ill health.

Our scientists can create **custom bioaerosols** and design and run experiments,, from R+D through to validation, to assess **technologies to manage** indoor air.

We collaborate with our clients, research partners and the built environment sector, to help them **accelerate solutions** for healthy indoor air.

We support **Technical Area 1 and 3**.

<https://airmidhealthgroup.com>

johnryan@airmidhealthgroup.com; emmag@airmidhealthgroup.com



Technical Area 2 (Respiratory Risk Assessment Software)

Technical and Programmatic POCs

Dr John McKeon
john@iair.institute

Emma Gribben
emma@iair.institute

iAIR Institute Overview

501(c)6 think-tank galvanizing leaders in

- consumer products
- building materials
- technology services

Promoting and enhance indoor air quality in

- Homes
- Commercial buildings
- Schools

Focused in transforming the way products, services, and indoor environments are conceptualized, created, and presented to optimize their impact on health.

Strengths & Capabilities

- Cutting-Edge Research
- Collaboration
- Problem-Solving and Innovation
- Regulatory and Policy Influence
- Market Intelligence
- Ethical and Sustainable Practices
- Risk Mitigation
- Long-Term Planning
- Networking and Partnerships

A dynamic community committed to promoting healthier indoor environments

Teaming Needs

The iAIR Institute is a prominent research center focusing on how the built environment influences and impacts on human health.

The iAIR Institute has capabilities which pertain to

- Technical Area 2 (Respiratory Risk Assessment Software).
- We are looking for teaming partners in
- the development of indoor air biosensors (TA1)
 - Healthy Building Controls and System Integration (TA3)



Contract Research Projects

- Bespoke consumer sentiment and landscape analysis on indoor air quality
- Enhancing indoor air quality for Firefighters
- Innovation audit for the new healthy building paradigm

2000 Gallons

We breathe over 2,000 gallons of air each day

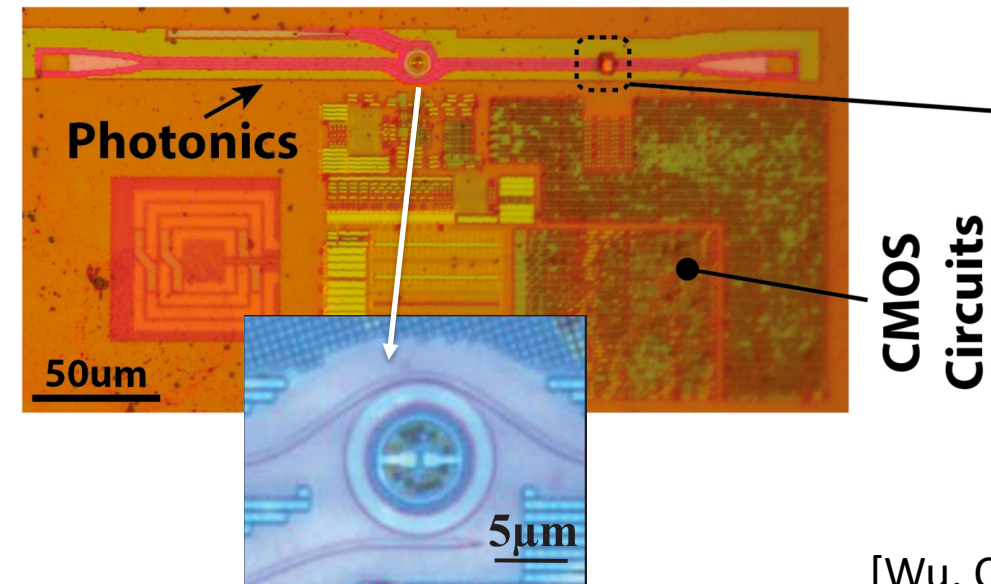
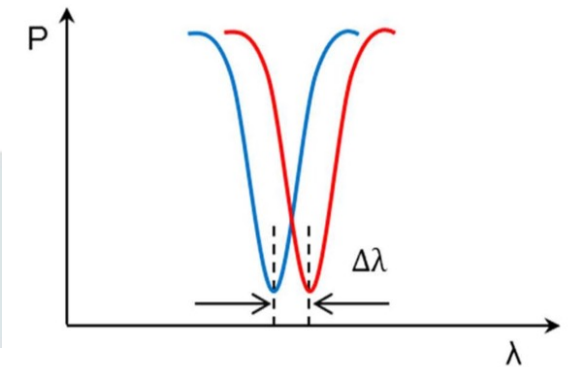
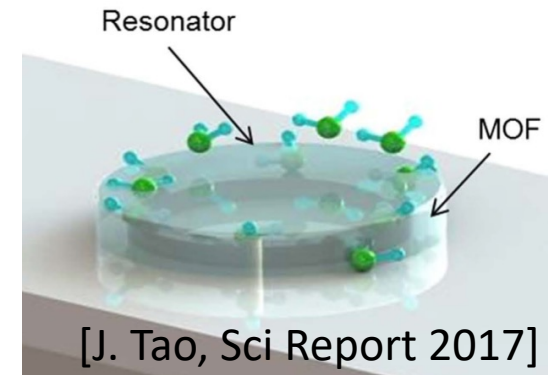
7 Million Deaths

Air pollution causes 7 million deaths globally annually

\$50 Billion

The yearly cost of asthma in the United States

- Photonic ring-resonator molecular/bio sensing
 - Ultra-sensitive (high-Q), Massive parallelism, Minimal sample size, Wash-free, and label-free
 - Commercial Use Case: Maverick™ Immunoassay Analyzer by Genalyte
- Our capabilities:
 - Silicon photonics design in commercial foundries (GF, AIM, & AMF)
 - Ultra-low noise and low-power CMOS readout and digital processing
 - Full electro-optical packaging & surface post-processing

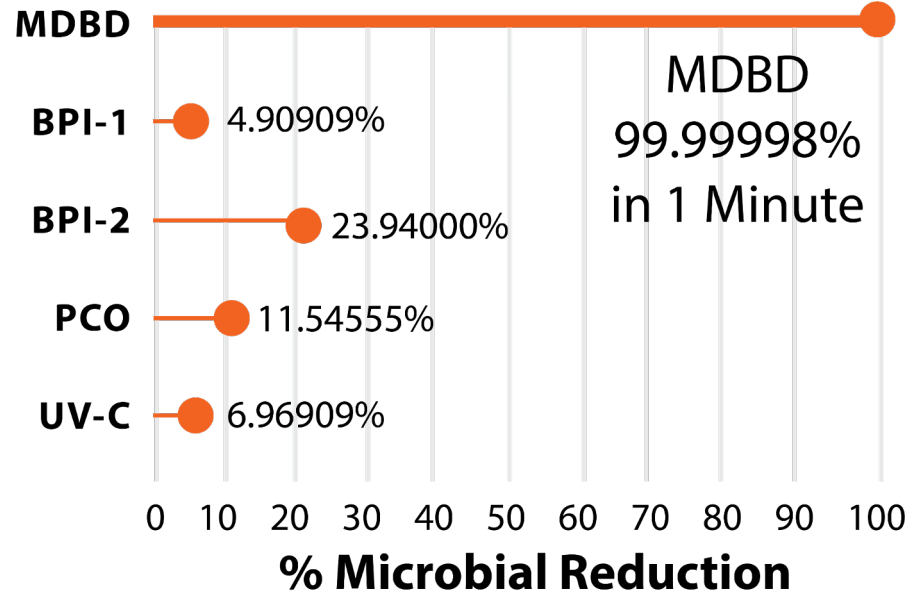


[Wu, CLEO 2023]



(F-9 Feline Calicivirus)

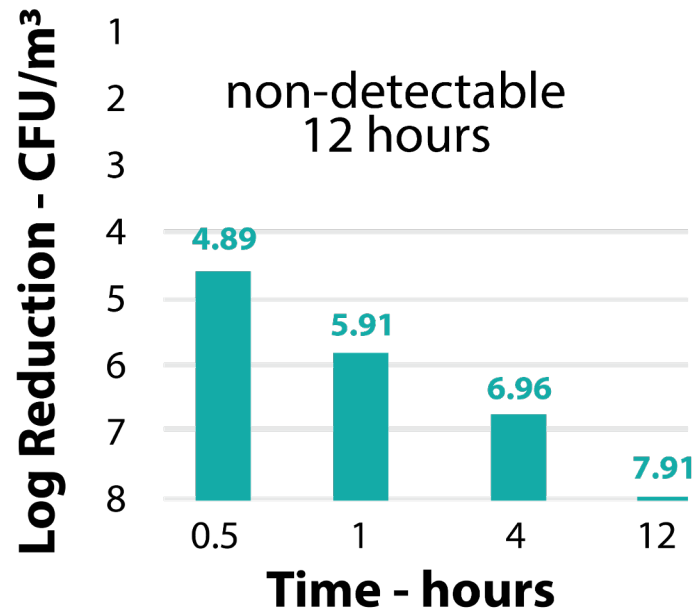
% Airborne VIRUS Reduction - 1 Minute



Lab Study - 2,640 ft³ Chamber
Financed by a consortium of clients

(Enterococcus faecium)

Log₁₀ Reduction Surface BACTERIA



Hospital Case Study

- TRL 9
- Fully scalable
- Fully automated
- Microbial & VOC mitigation
- IoT capable
- 100s of efficacy evaluations
- Safety Validated
- UL2998 (zero ozone)
- Low energy use
- Accessible to broad populations
- USDA NOP approved

Seeking TA1, TA2 and TA3
Building Control Partners

HVAC integrated, wall mount, or stand-alone



**UNIVERSITY OF
CAMBRIDGE**

Department of Engineering

Trinity Bradfield Prize

EPSRC Impact Acceleration Award

Stanford | **ENGINEERING**
Mechanical Engineering

Innovate UK iCure Xplore

Founders @ Cambridge



AETOSENSE

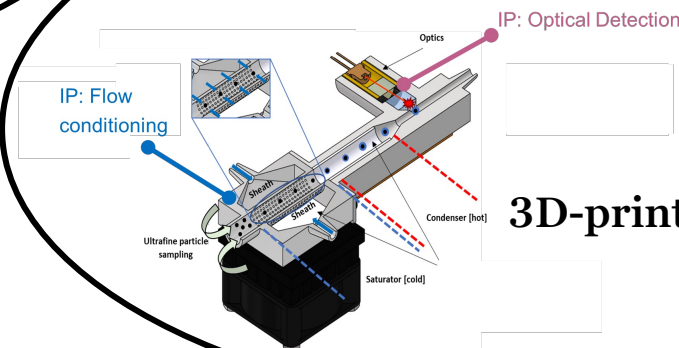
Who we are

Prototyping experts
Miniaturization experts
Microfluidics experts
Optics experts

Who we need

TA1: Biosensor experts
TA2: Software developers
TA3: Buildings experts

Our technology - The Mini CPC



1/10th price
1/10th size
3D-printing compatible

OpenAeros

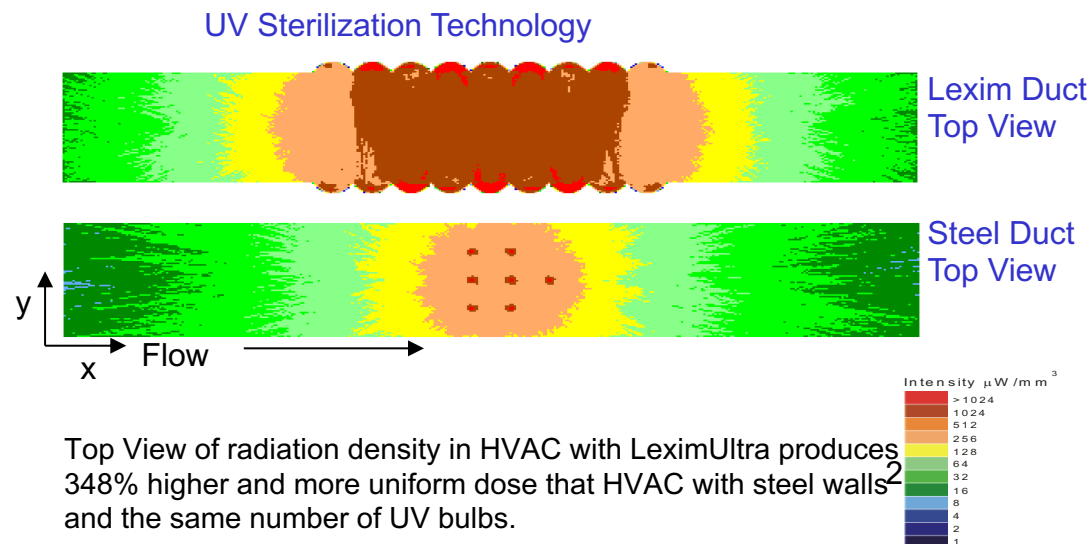
- Founded in 2022 to develop tools for a clean air revolution
 - To enable rapid adoption at a global scale:
 - Cutting edge manufacturing technologies
 - Low-cost
 - Open source
- The OpenAeros team:
 - Expertise in:
 - aerosol science, instrumentation, and indoor air quality
 - electronic, mechanical, optical, and materials design capability
 - Onsite resources:
 - Fully equipped in-house mechanical and electronics rapid prototyping, aerosol and electronics metrology lab and in house high volume manufacturing facility.
 - An established and tightly-integrated network of global partners and contract manufacturers



Lexim Biophotonics' proprietary technologies support ***rapid and sensitive detection*** of a broad range of infectious agents as well as enhanced U.V. technology for ***more effective air sterilization***.

Pathogen Detection Technology

- **Rapid detection <5min** of broad range of pathogens based on spectral fingerprint
- **Emerging pathogens can be added** to the database same day as isolated
- **Simple and inexpensive** detection method
- No additional sample manipulation, reagents required



- **Adaptable** to any HVAC UVC system to achieve lower cost of operation
- **Extremely uniform** UVC energy distribution with less energy loss in HVAC
- **Performance testing 3-14X** better than standard steel ducting
- **More effective** pathogen sterilization

Particulate Matter Sensing and Analysis Using Deep Learning Digital Inline Holography



Deep Learning Digital Inline Holography (DIH)

- DIH excels in measuring a wide array of microparticles suspended in **any transparent fluid, without requiring in-focus images**—enabling **sampling volumes up to 1000 times larger than conventional microscopy**.
- This technology provides **label-free** analysis, preserving the natural state of particles.
- Integration with deep learning allows for **real-time analysis of optical properties**, enabling precise determination of particle **size and morphology**, as well as **complex highly specific classification (bacteria type, viability, and more)**
- **Broad Operational Range:** particle sizes from submicron to over mm and providing real-time detection and classification for concentrations up to 1000 particles/mL.
- **Low-Cost and Compact Design:** Systems can be designed for well under \$1000, while being extremely compact, with some sensors as small as a quarter.
- **Easy to deploy and operate without specialized training.**

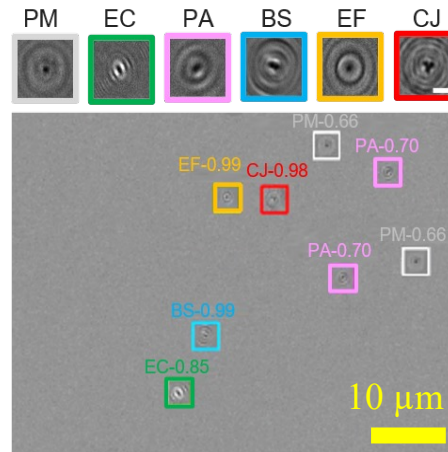
Real-time monitoring and assessment

- All-in-one: particle counting, sizing, classification
- Processing is done by a GPU laptop in real-time
- Software tools for user friendly in-depth data capture and processing



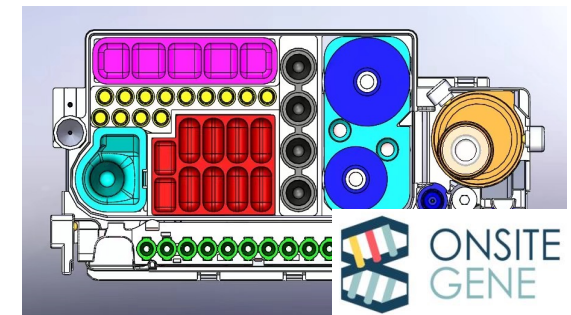
DIH Classification:

- Real-time Differentiation of 5+ bacteria species, and sterile particles



Integration with downstream assay technologies:

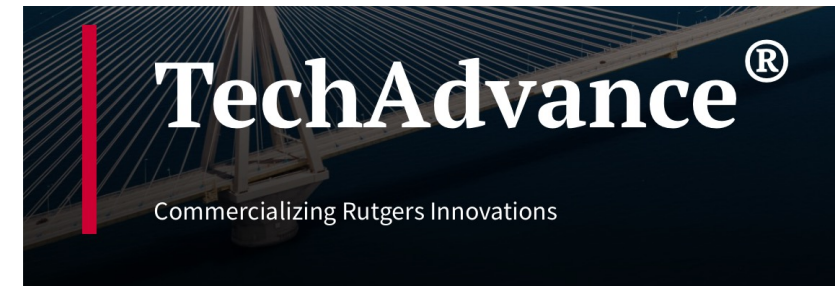
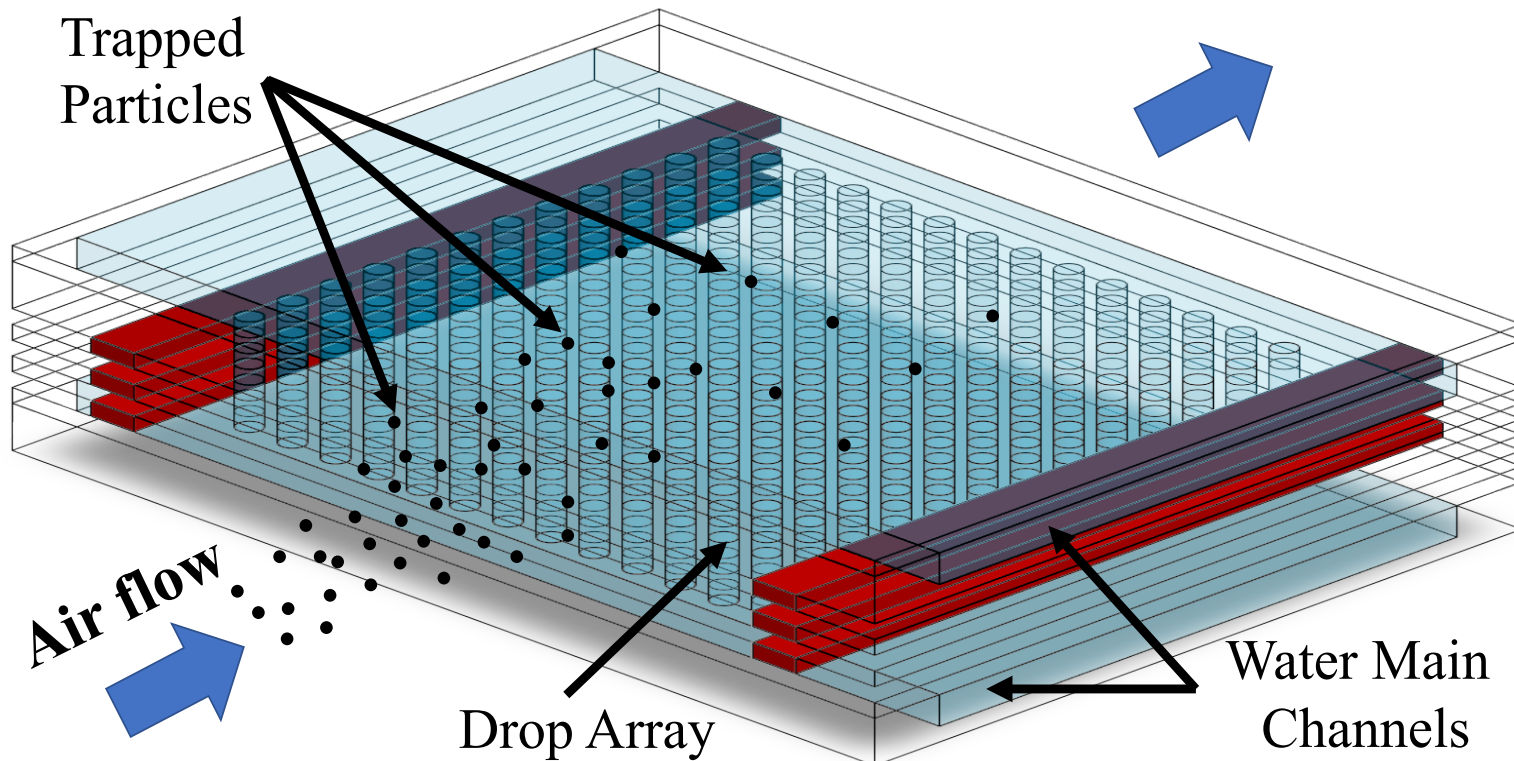
- Autonomous real-time PCR (**PeakV-AIR**)
- Droplet based microfluidic systems





AQUACOMB

Renewable and programmable liquid membranes for filtration of airborne particulates and aerosols



BREATHE Challenge	Solution for BREATHE
45-minute detection delay leaves ample time for airborne viruses to infect many people	Air cleaning at 5 or more air changes per hour recommended by CDC in 2023
Air cleaning removes most pathogens from the air diminishing operational sensitivity of bio detectors	Pathogens captured inside filters from air purifiers (e.g. DIY) can be recovered by vacuuming air filter into a second sampler filter for lab analysis.
Targeted detection of pathogens not actionable if unable to tell apart animal vs human such as H5N1 (happening today in wastewater)	SNP-accurate, agnostic sequencing based on hybrid capture demonstrated for 97 viral species by Texas group (but takes 1-2 days)
Accurate agnostic sequencing (depth) is too costly on a daily basis	Spike-triggered virtualization modulates depth in response to pathogen spikes

References: (Patient Knowhow)

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