EPA Office of Research and Development

HOMELAND SECURITY RESEARCH

COVID-19 Research: Ozone and Aerosol Treatment

HSRP Webinar Series
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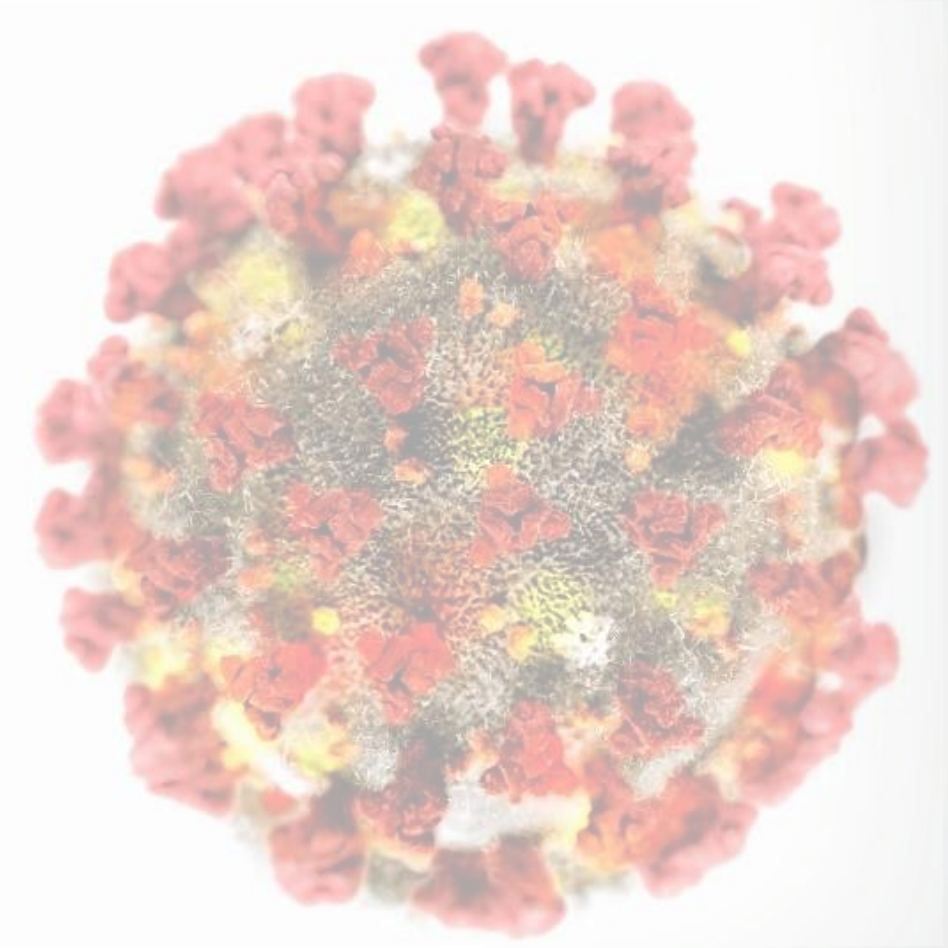
Outline

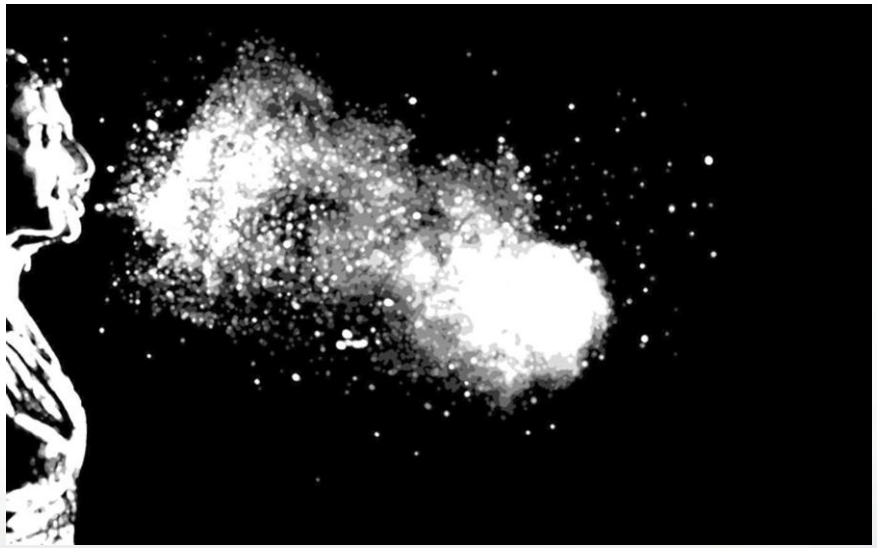
- Ozone: Disinfection of Surfaces
  - Research Objectives
  - Background
  - Setup and Test Matrix
  - Results
- Aerosol Treatment Research
  - Background and Research Objectives
  - Methods and Test Chamber
  - Results
    - Bipolar Ionization
    - Grignard Pure
    - 3-Stage Air Filtration and Purification System



Aerosol Transmission and COVID-19

- Studies have documented the spread of COVID-19 in enclosed spaces (e.g., buses, hospital rooms, restaurants, offices)
- Growing focus on the transmission of COVID-19 via aerosolized SARS-CoV-2
- Increasing focus on **air treatment technologies**
  - Many technologies are devices, which are not registered by EPA.

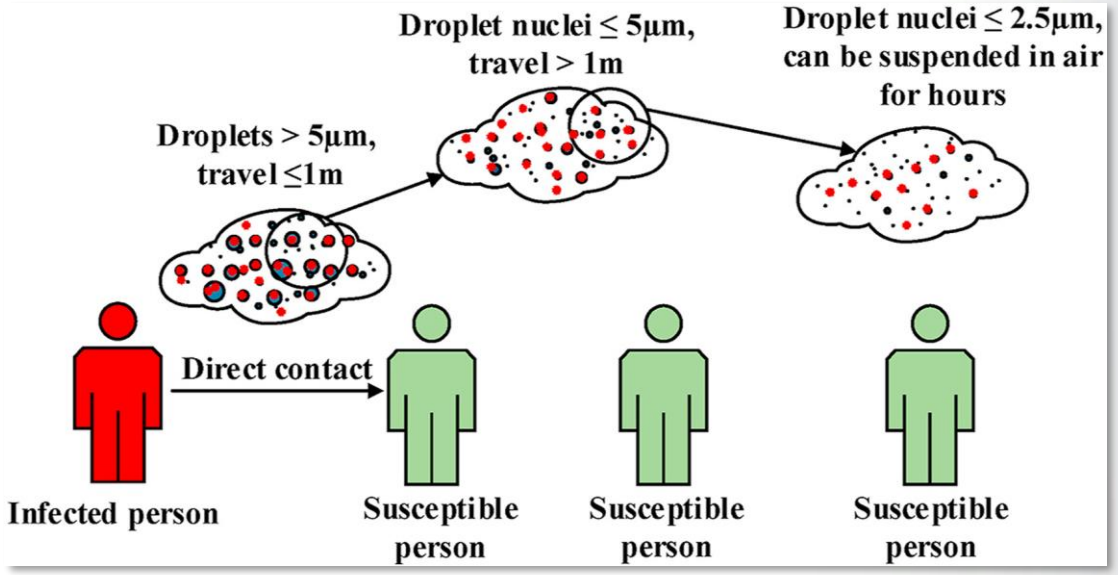
- **Challenges:**
  - Growing need and desire repopulate indoor spaces (schools, offices, restaurants, public transit, events and gatherings, etc.)
  - Social distancing not always feasible
  - Many air cleaning technologies on the market, lack of independent testing data



Aerosol Treatment: Project Objectives

- How effective are commercially-available aerosol treatment technologies at reducing concentrations of infectious SARS-CoV-2 in the air?

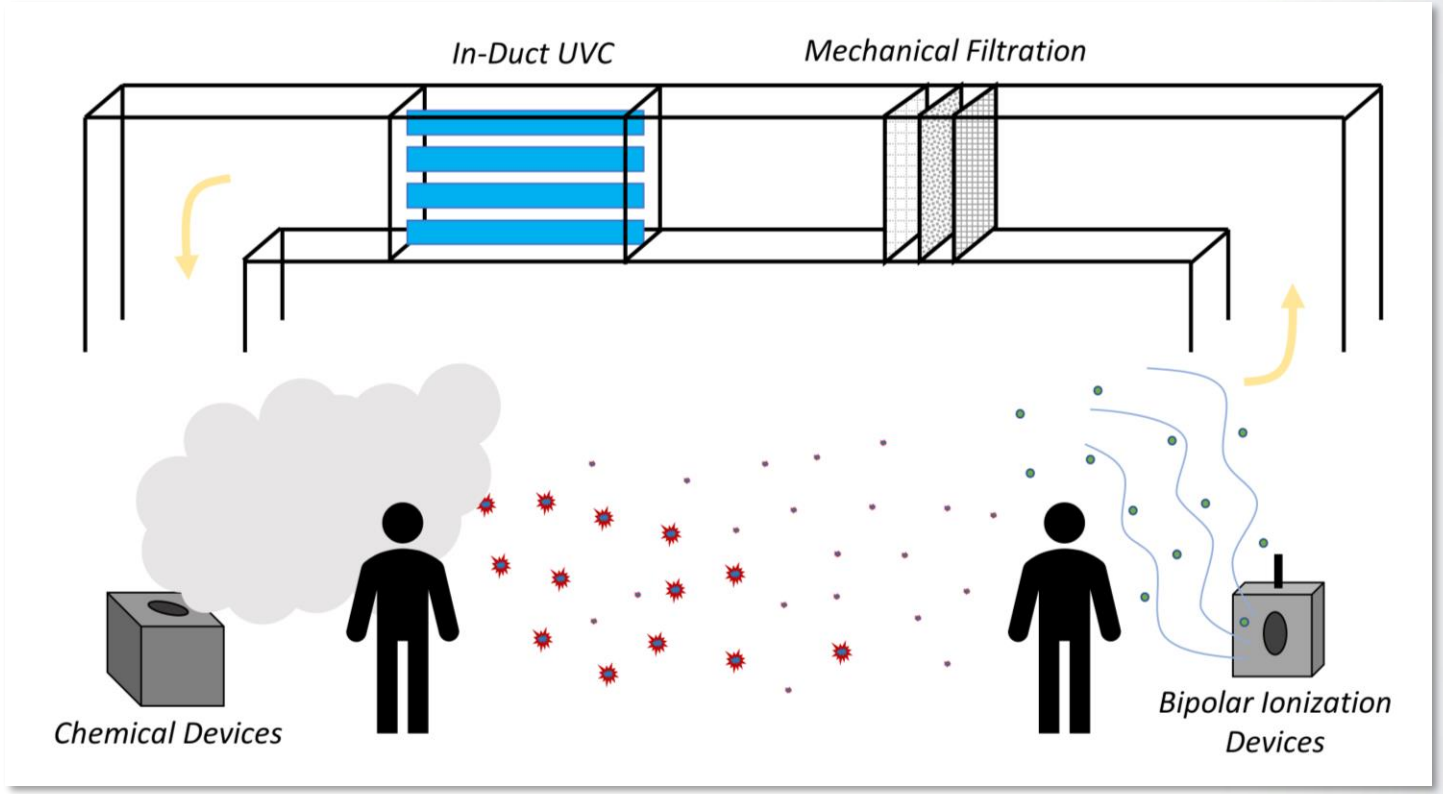
- **Research Goals:**
  - Assess efficacy of aerosol treatment products and devices at a real-world scale
  - Develop reliable and standardizable methods for testing air treatment technologies
  - Establish expertise to extrapolate understanding of treatment technologies to inform estimation of efficacy of novel, untested technologies



Niazi et al. (2020), *Environmental Pollution*

Aerosol Treatment Technologies

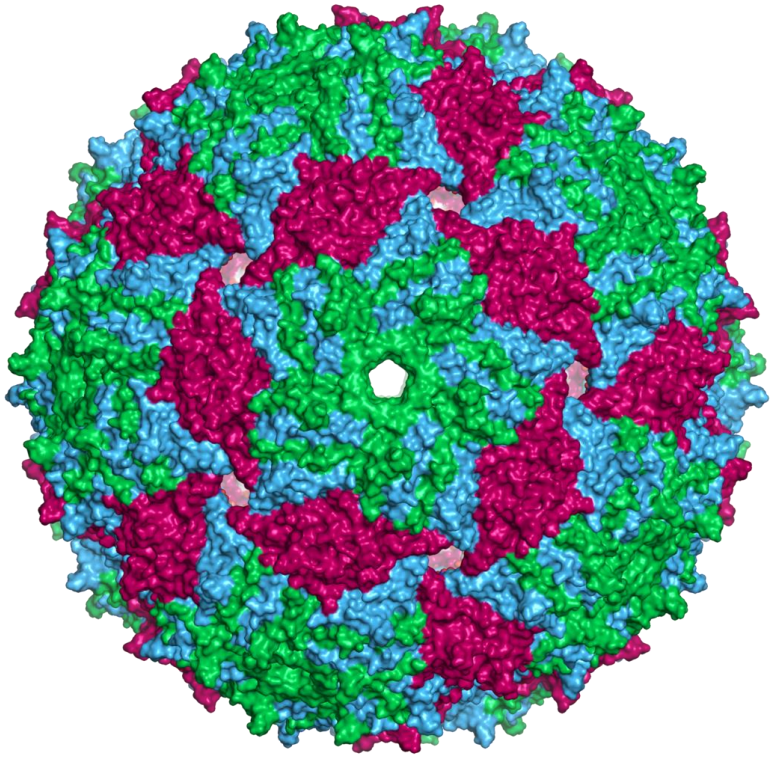
- UVC devices: e.g., upper-room germicidal UVC, in-duct UVC
- Chemical products and devices: in-room or in-duct; e.g., low-concentration ozone, low-concentration hydrogen peroxide, bipolar ionization
- Physical removal: e.g., MERV-13 and specialized filters, portable air cleaners
- Combinations of the above



Focus on air treatment technologies and methods that can be continuously operating in occupied spaces (in-room or in-duct)

Aerosol Treatment: Methods

- Evaluate efficacy of technologies against non-pathogenic virus (MS2)
  - Expected to be more resistant to chemical inactivation than SARS-CoV-2



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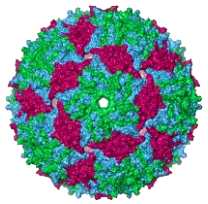
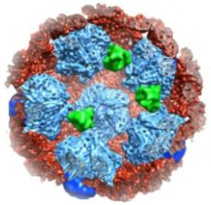
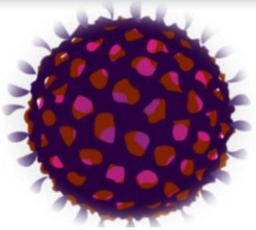
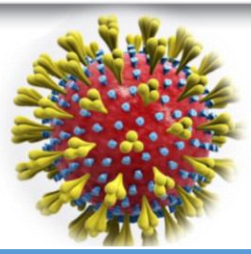
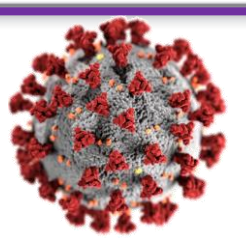
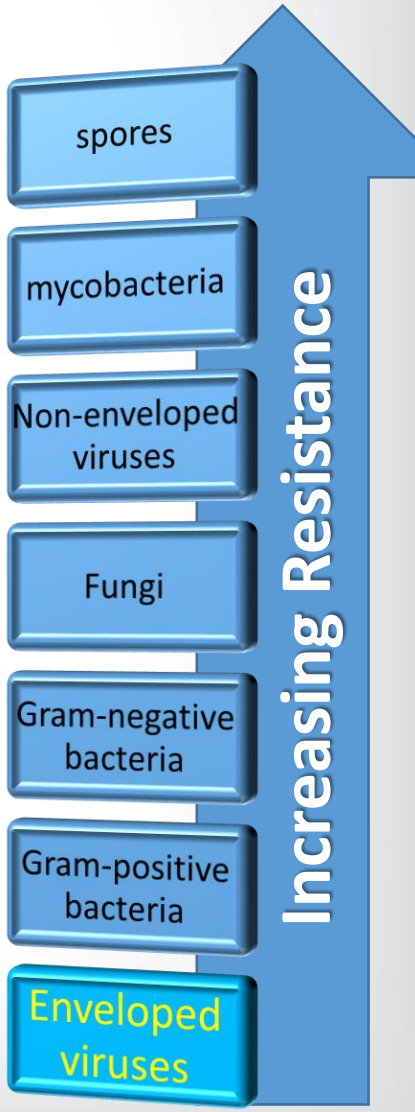
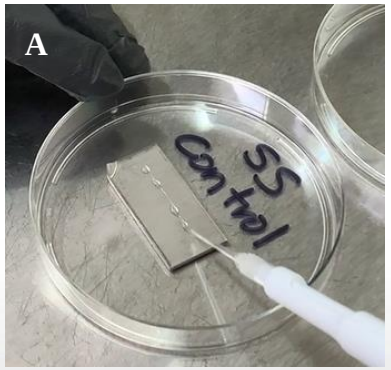
Aerosol Treatment: Methods

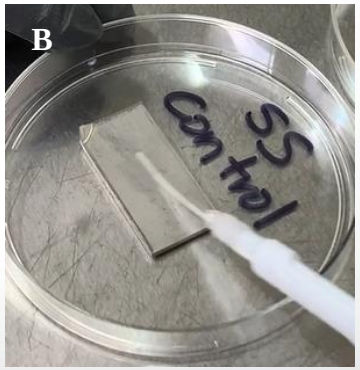
					
	MS2	**Phi6**	**MHV**	**229E**	**SARS-CoV-2**
Enveloped?	No	Yes	Yes	Yes	Yes
Host	Bacteria (*E. coli*)	Bacteria (*P. syringae*)	Mice	Humans	Humans
Genus	Levivirus	Cystovirus	Betacoronavirus	Alphacoronavirus	Betacoronavirus
BSL	1	1	2	2	3
Advantage	High resistance & persistence, fast and easy analysis	Moderate resistance & persistence, fast and easy analysis	Same genus as SARS-CoV-2, non-human pathogen	Same Family as SARS-CoV-2	Actual agent of COVID-19
Surrogate?	Comparison in progress			Regulatory surrogate	



Aerosol Treatment: Methods

- Evaluate efficacy of technologies against non-pathogenic virus (MS2)
  - Aerosolized using 6-jet Collison nebulizers
    - Count median diameter of aerosolized particles ~45 nm at the beginning of each test; increases in size over duration of test (100 nm at 120 min)
  - Air sampling:
    - SKC BioSamplers (enumerated via plaque assay)
    - CCDC-CBC TACBIO 2 (real-time)
  - Surface sampling:
    - Inoculated 2 cm x 4 cm stainless-steel coupons
    - Clean stainless-steel coupons for deposition
    - 5 pairs co-located on chamber floor
  - Onsite microbiology lab
  - Particle size & count measurements





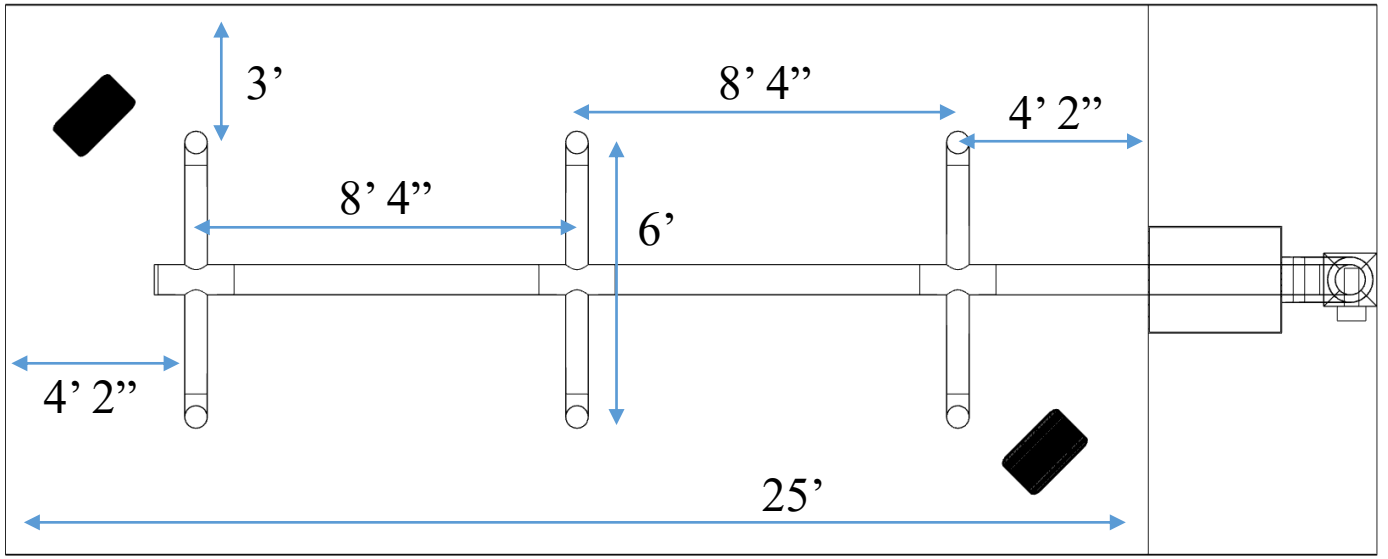
Aerosol Treatment: Methods

- Evaluate efficacy of technologies against non-pathogenic virus (MS2)

- Utilize specialized Aerosol Test Facility in Research Triangle Park, NC
  - Large air treatment test chamber 10 x 12 x 25 ft (3000 ft^3)
  - Controlled temperature / humidity
    - 22 ± 2 °C
    - 30-35 % RH
  - Mixing fans

Aerosol Treatment: Methods

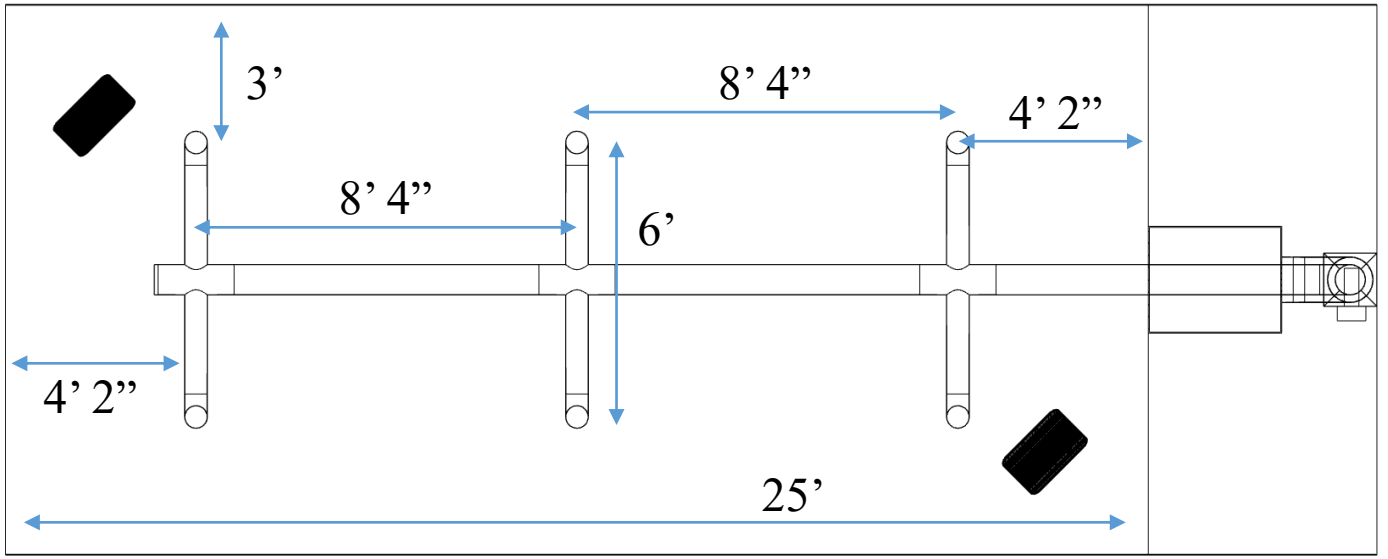
- Evaluate efficacy of technologies against non-pathogenic virus (MS2)
- Utilize specialized Aerosol Test Facility in Research Triangle Park, NC
- Mock HVAC system designed and installed for evaluating technologies
  - Negative air machine simulates mock cold air return with adjustable flow
    - 350 CFM, ~7 air changes per hour
  - Six branches (6”) from main line (8”), each outlet fitted with diffuser
  - Galvanized steel duct materials



Aerosol Treatment: Methods

- Evaluate efficacy of technologies against non-pathogenic virus (MS2)
- Utilize specialized Aerosol Test Facility in Research Triangle Park, NC
- Mock HVAC system designed and installed for evaluating technologies

Testing objective: Obtain high enough recoveries in control conditions throughout duration of testing to demonstrate a 3-$\log_{10}$ reduction



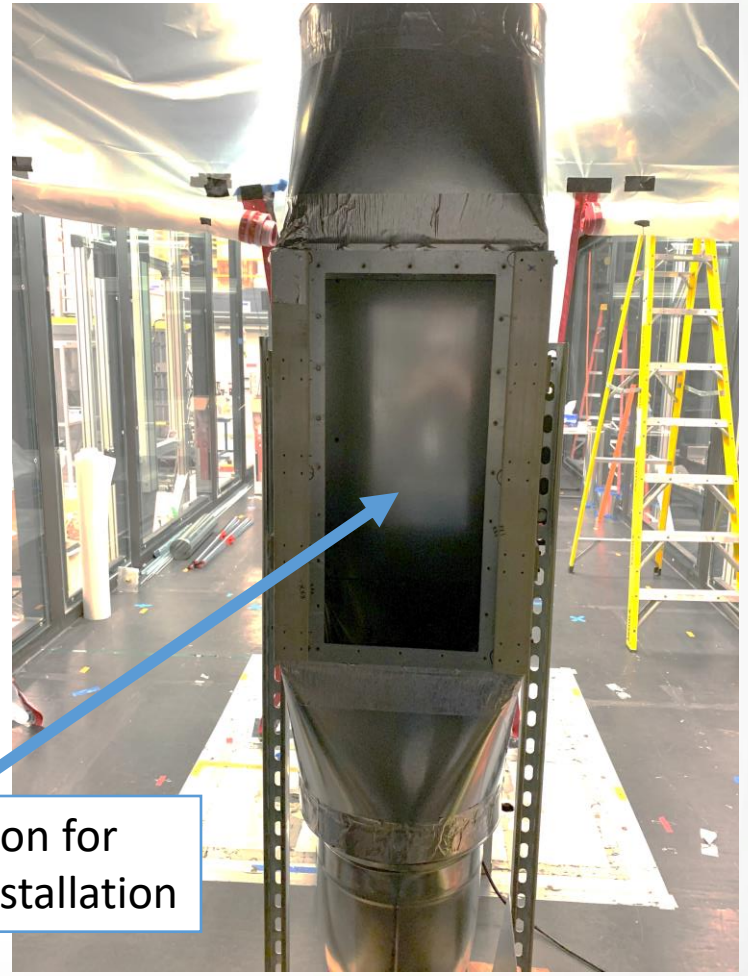
Aerosol Treatment: Technologies

	Technology Type	Intended Use
✓	Bipolar Ionization	Installed in-duct; intended for residential, commercial, industrial, education, health care settings
✓	Grignard Pure (active ingredient: Triethylene Glycol)	Dispersed either in-room or in-duct; intended for use in indoor spaces for essential economic activities as determined by the state; e.g., health care, transportation, food processing
✓	Knorr 3-Stage System: Electrostatic Filter, UVC, and Bipolar Ionization modules	3-stage air filtration and purification system designed to be installed (either new or as retrofit) in the HVAC system of rail transit vehicles; plan to evaluate components operating together & in isolation
*	Photocatalytic	General indoor use; transit vehicles
*	Filtration	For use in residential, commercial, transit settings

** Testing ongoing in August 2021*

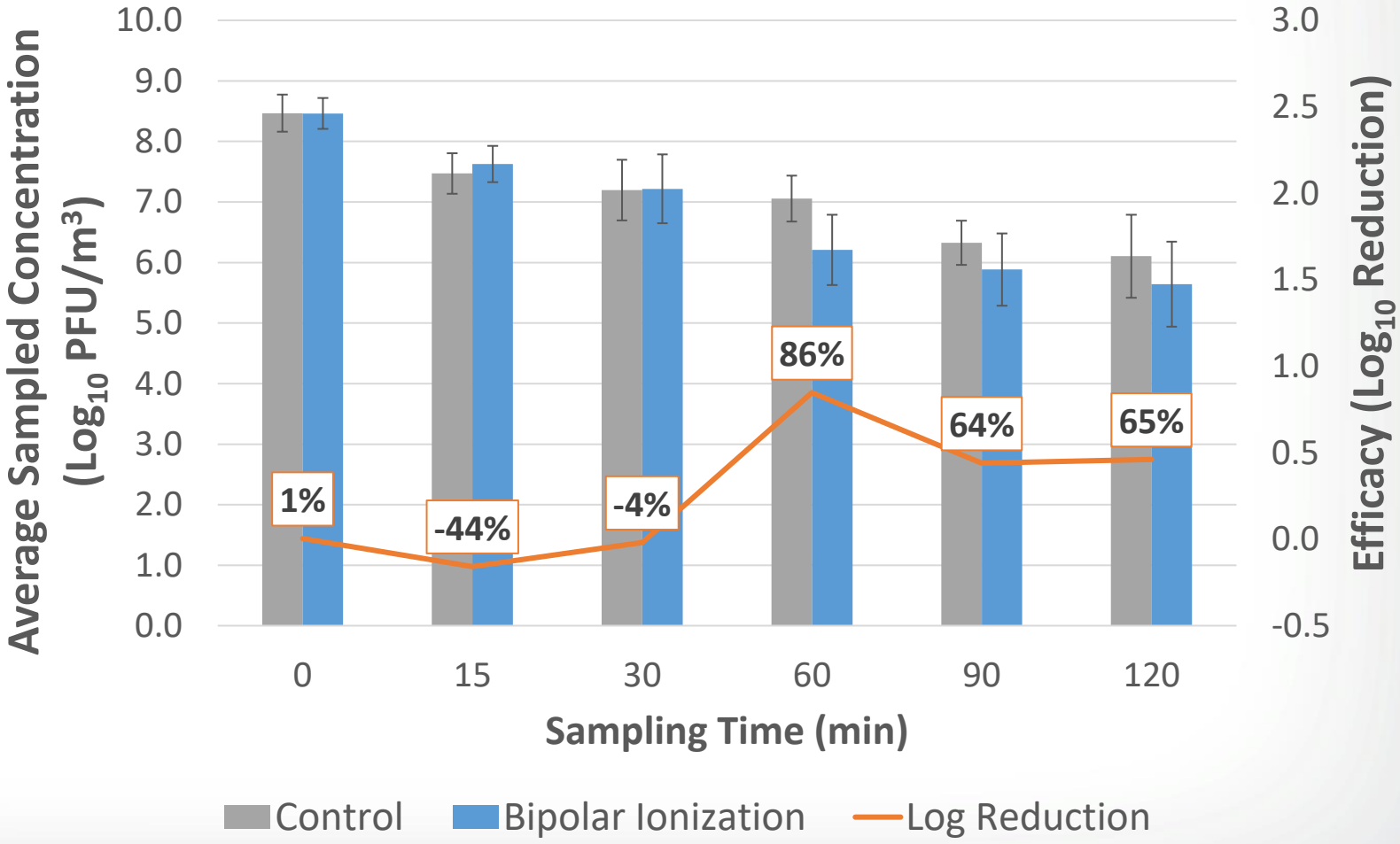
Bipolar Ionization Device

- Bipolar ionization generates charged ions that react with airborne contaminants, including viruses
- Cold plasma bipolar ionization device selected for evaluation
  - Sized to treat 2000-4000 ft^2 of living space
- Installed in-duct
- 30 to 90-minute ion buildup times in chamber prior to testing, resulting in ion counts of 1000-6000 ions/cm^3



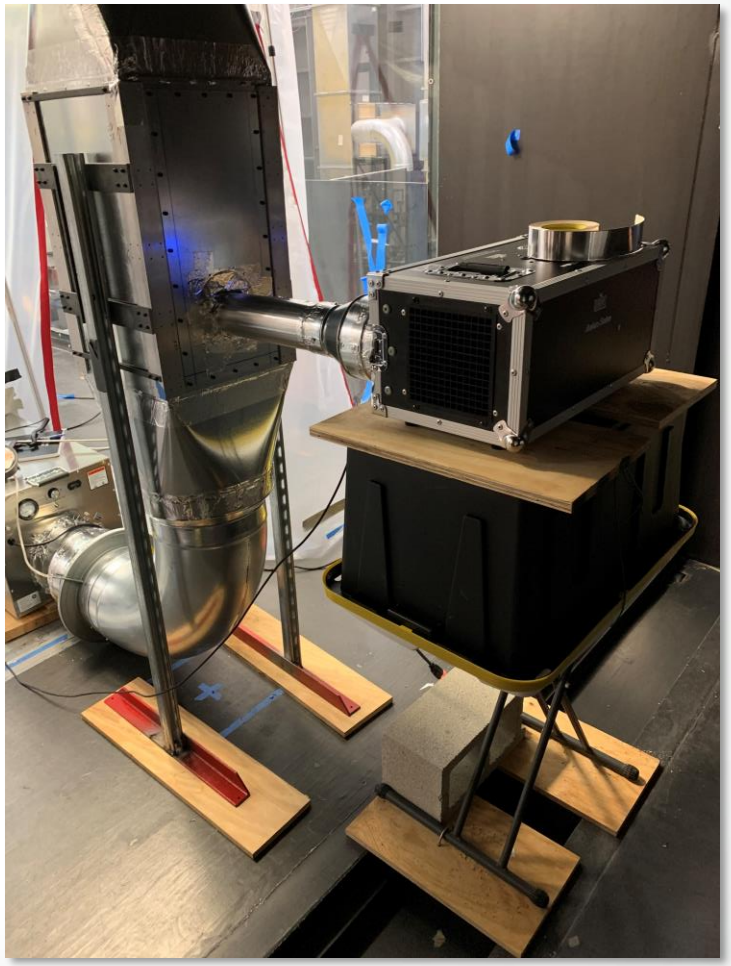
Bipolar Ionization Device

- Average log_{10} reductions in aerosolized MS2 from initial tests range from -0.16 to 0.85 throughout test duration
- No additional virus recovered from surfaces
- No surface inactivation observed

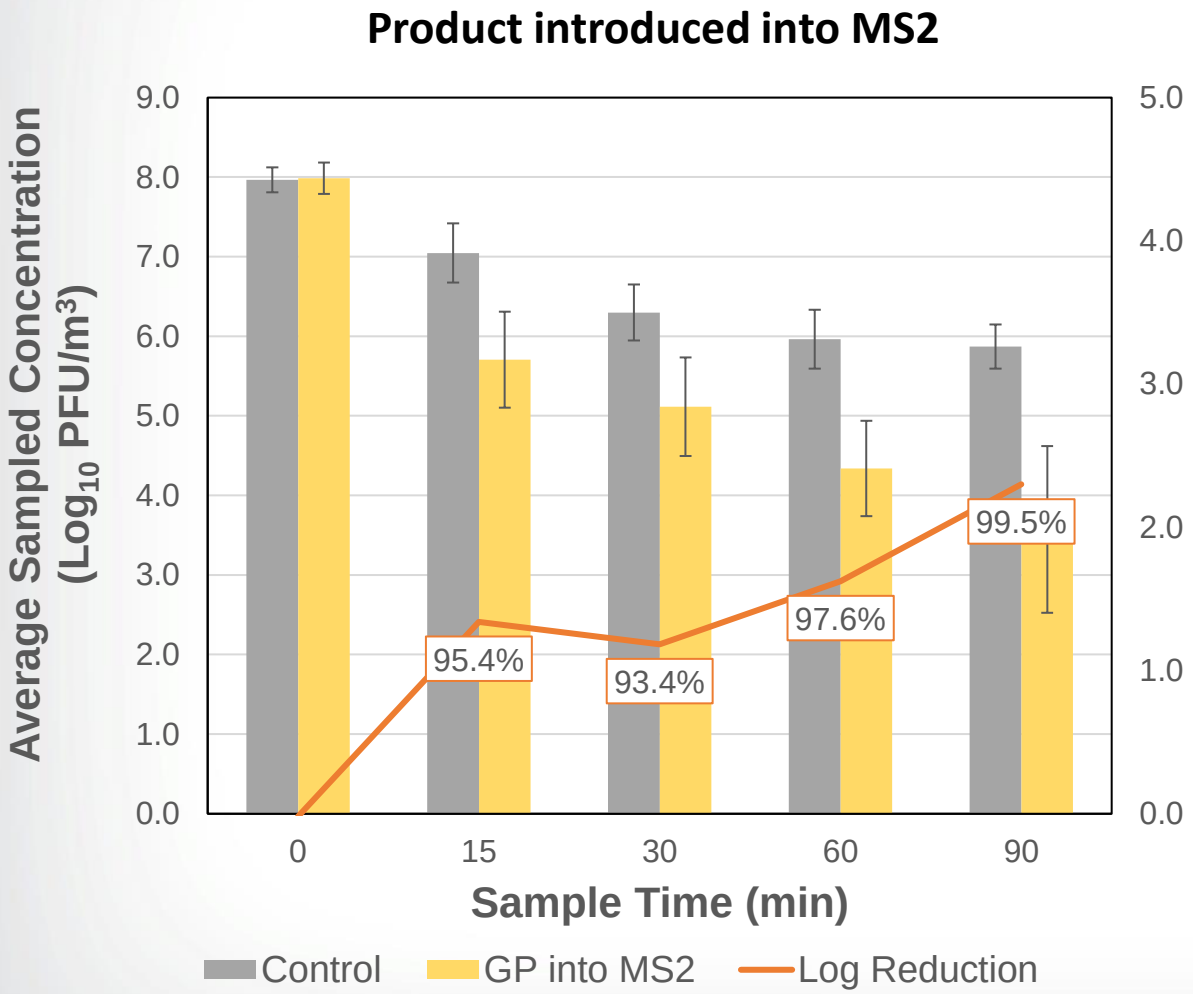


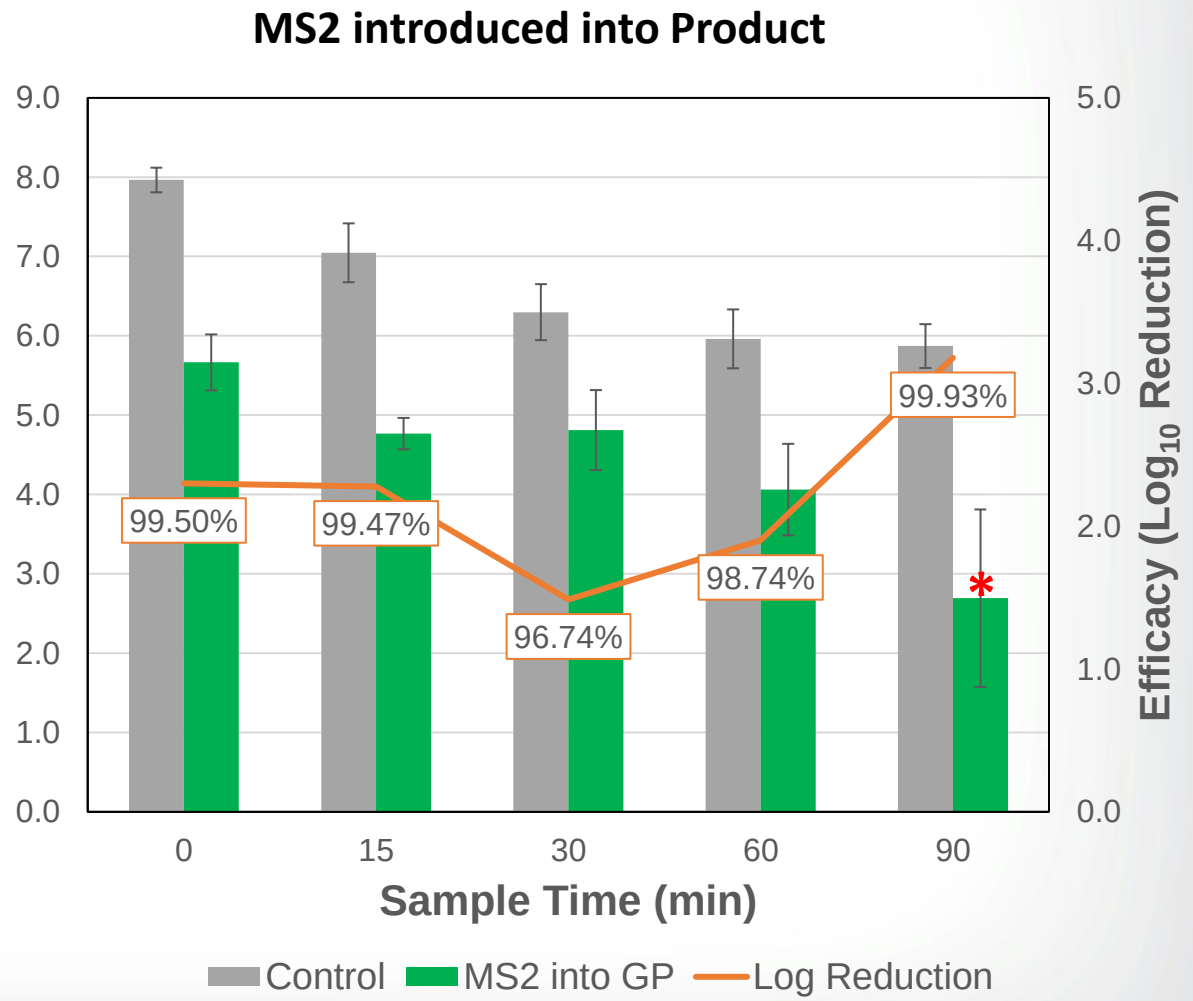
Grignard Pure

- Antimicrobial air treatment product
  - Section 18 Emergency Exemptions for indoor use in GA, MD, NV, PA, TN, TX
- Triethylene glycol (TEG) active ingredient
  - Commonly used in theatrical fog machines
  - Historic publications on air disinfection date to 1940's
  - 1.2 – 1.5 mg/m^3 concentration of TEG during testing (NIOSH Method 5523)
- Two different test sequences evaluated:
  - Introduce product into aerosolized MS2
  - Introduce MS2 into product in chamber already at target concentration



Grignard Pure

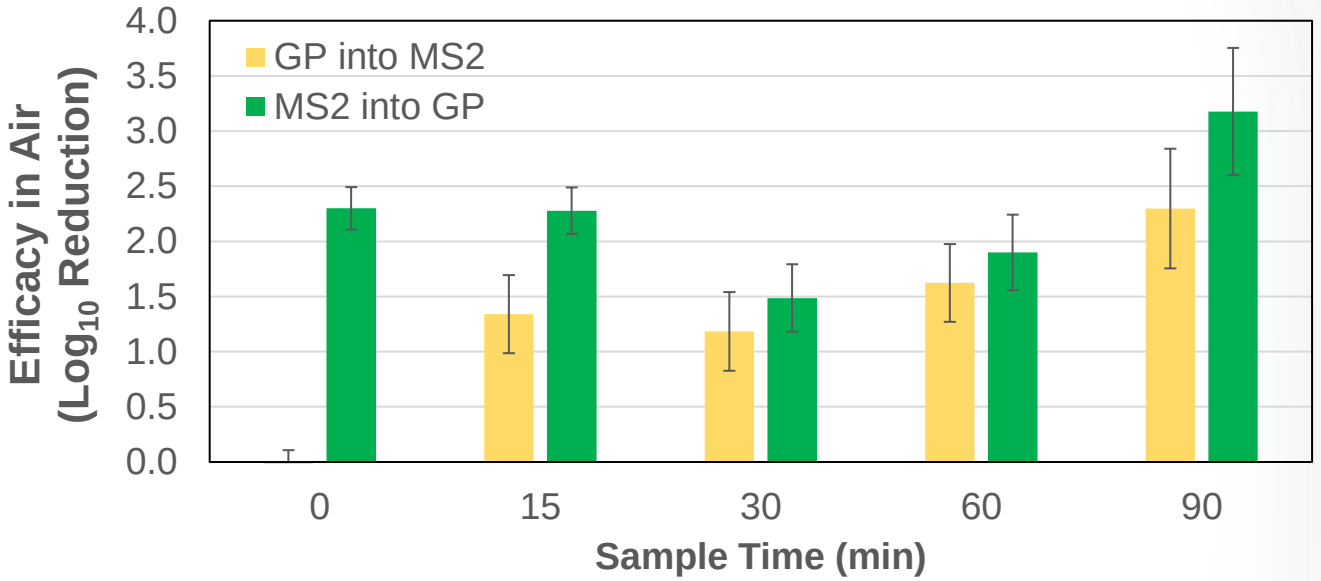


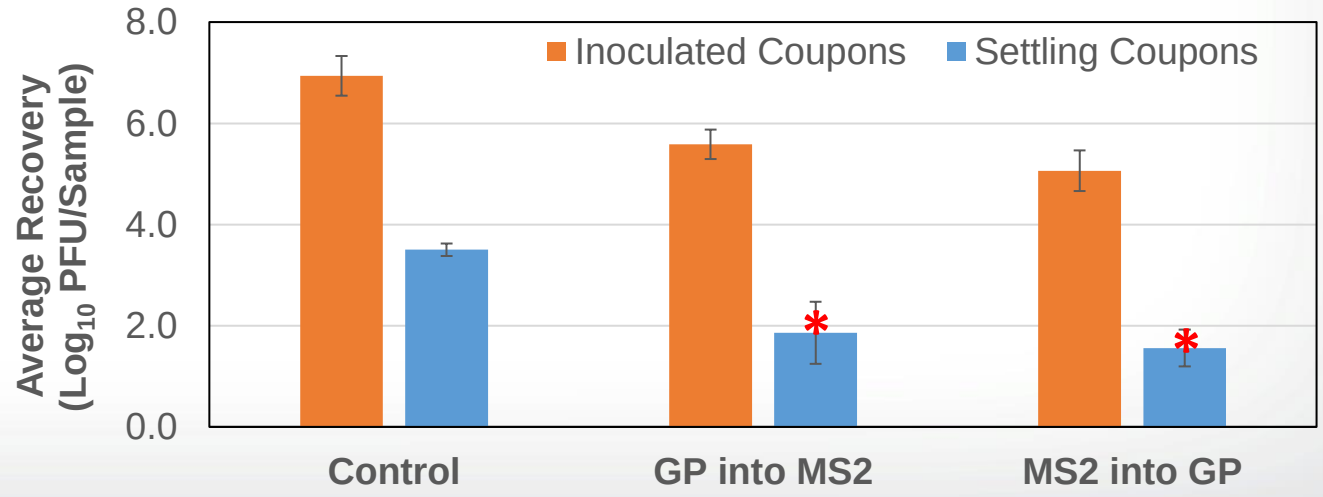


** 2 of 4 replicates at LOD*

Grignard Pure

- Higher calculated efficacy when MS2 aerosolized with product present in test chamber
- Surface inactivation observed on inoculated coupons
  - GP into MS2: average $\log_{10}$ reduction 1.6 ± 0.4 PFU/coupon
  - MS2 into GP: average $\log_{10}$ reduction 1.9 ± 0.2 PFU/coupon
- Reduced MS2 recoveries on deposition coupons



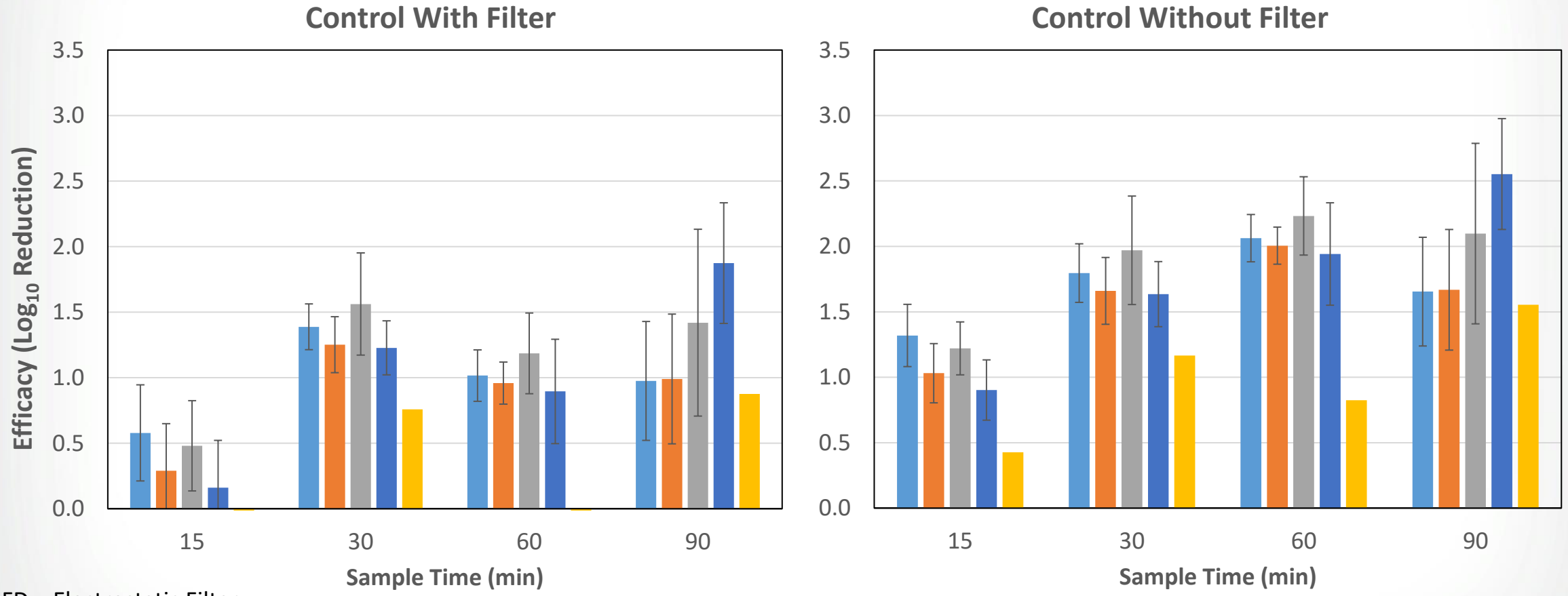


** Some replicates at LOD (1.0 $\log_{10}$ PFU/Sample)*

3-Stage Air Filtration & Purification

- System developed by Knorr Brake Company for transit vehicles
  - Electrostatic filter – Merak Intense Field Dielectric (MIFD) filter
  - Bipolar ionization – Merak Dielectric Barrier Discharge (MDBD) device
  - UV-C radiation – low-pressure mercury vapor lamp (wavelength = 254 nm)
- Test unit in center of chamber
  - Knorr blower: ~25 air changes per hour
  - Recirculating HVAC still operating
- Controls with and without MIFD arrest filter

3-Stage Air Filtration & Purification



MIFD – Electrostatic Filter
MDBD – Bipolar Ionization
UV – 254 nm UV-C Source

Aerosol Treatment Conclusions

- Efficacy of different types of air treatment technologies can be evaluated using similar testing methodologies
  - Demonstrated efficacies range from < 1-log reduction to > 3-log reduction, depending on technology type and test sequence
- Testing at large scale needed to extrapolate results to real world
  - Still need to consider many other factors, such as temperature/humidity, HVAC system design, air change rates, etc.
- Design of control conditions impacts calculated efficacy

- *<u>Next steps</u>: evaluate photocatalytic devices and filters (August 2021)*