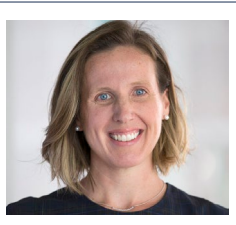




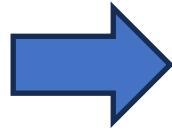
# **Wearable Air Curtains: Novel Respiratory Protection Against Airborne Pathogens**

# Opportunity + Complementary Collaborators = Innovation

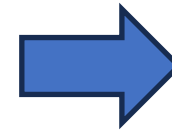
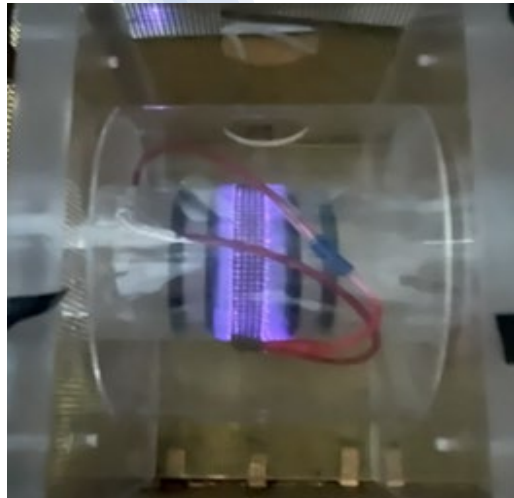
2012



+



2017



2019



Funding:



United States Department of Agriculture

M E D C

MICHIGAN ECONOMIC  
DEVELOPMENT CORPORATION



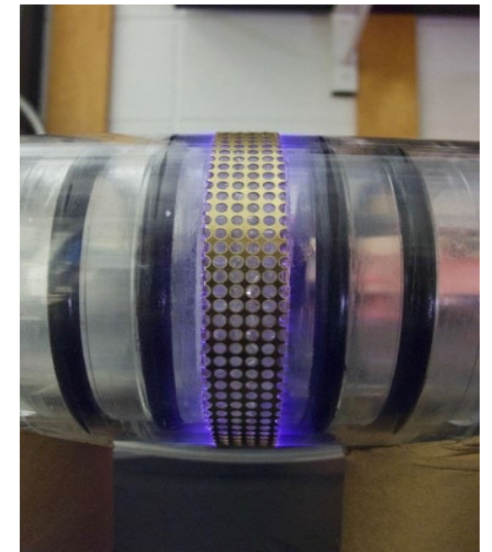
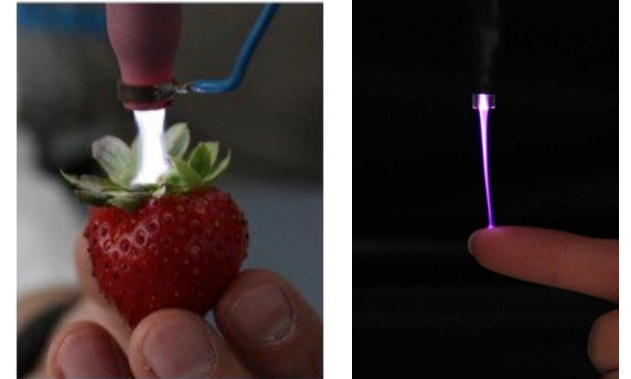
National Pork Board



SBIR/STTR  
SMALL BUSINESS INNOVATION RESEARCH  
SMALL BUSINESS TECHNOLOGY TRANSFER

# Non-thermal plasmas (NTPs) for air disinfection

- A non-thermal plasma is an ionized (charged) state of matter, induced by imposing strong electric, magnetic fields
  - used in electronics, fabrication of microelectronics, chemical catalysis
- Air disinfection by NTP exposure is challenging:
  - short exposure times (100s of msec)
  - possible interference phenomena (charged aerosols, EHD)
  - deep dilution from liquid nebulization into air, impacting LOD\
  - ozone mitigation
- NTP treatment of viral aerosols presents additional challenges
  - indirect assays involving effects on host organism
  - tedious propagation, purification, and enumeration



# Performance Comparison

## Non-thermal Plasma vs. UV-C and HEPA filters

|                    | HEPA Filter <sup>1</sup>             | UV-C <sup>2</sup>   | NTP <sup>3</sup>                     |
|--------------------|--------------------------------------|---------------------|--------------------------------------|
| Pathogen reduction | 97%                                  | 99%                 | > 99%                                |
| Air flow rate      | 36 LPM                               | 60 LPM              | 170 LPM                              |
| Pressure drop      | 60 Pa<br>(0.24 in. H <sub>2</sub> O) | N/A                 | 45 Pa<br>(0.18 in. H <sub>2</sub> O) |
| Flow area          | 3100 cm <sup>2</sup>                 | 20 cm <sup>2</sup>  | 71 cm <sup>2</sup>                   |
| Treatment volume   | 7874 cm <sup>3</sup>                 | 550 cm <sup>3</sup> | 181 cm <sup>3</sup>                  |

<sup>1</sup> Zhang et al., *ASHRAE J.*, August 2020

<sup>2</sup> Tseng and Li, *Aerosol Sci. Tech.* **39** (2005), 1136

<sup>3</sup> Xia et al., *J. Physics D* **52** (2019), 255201

# Performance Comparison

## Non-thermal Plasma vs. UV-C and HEPA filters

|                    | HEPA Filter <sup>1</sup>             | UV-C <sup>2</sup>   | NTP <sup>3</sup>                     | NTP Advantage         |
|--------------------|--------------------------------------|---------------------|--------------------------------------|-----------------------|
| Pathogen reduction | 97%                                  | 99%                 | > 99%                                | Greater               |
| Air flow rate      | 36 LPM                               | 60 LPM              | 170 LPM                              | 2.8X - 4.5X higher    |
| Pressure drop      | 60 Pa<br>(0.24 in. H <sub>2</sub> O) | N/A                 | 45 Pa<br>(0.18 in. H <sub>2</sub> O) | 25% lower than HEPA   |
| Flow area          | 3100 cm <sup>2</sup>                 | 20 cm <sup>2</sup>  | 71 cm <sup>2</sup>                   | 44X smaller than HEPA |
| Treatment volume   | 7874 cm <sup>3</sup>                 | 550 cm <sup>3</sup> | 181 cm <sup>3</sup>                  | 3X – 44X smaller      |

<sup>1</sup> Zhang et al., *ASHRAE J.*, August 2020

<sup>2</sup> Tseng and Li, *Aerosol Sci. Tech.* **39** (2005), 1136

<sup>3</sup> Xia et al., *J. Physics D* **52** (2019), 255201

Key advantage for miniaturization

# October 2019: JLab & BARDA launch Invisible Shield QuickFire Challenge



- Goal: “.... solutions that repel and protect against airborne viruses while integrating seamlessly into everyday life.”
- Taza Aya’s plasma-enabled wearable air curtain concept would feature:
  - no need for fit testing
  - no breathing resistance
  - protection for all ages, face shapes, and with facial hair
  - protection while eating, drinking
  - no fogging of glasses or goggles
  - no contact irritation of skin or sore ears
  - unimpeded communication for DHH and bilingual or heavily accented speakers

## Funding:

Johnson & Johnson INNOVATION | JLABS



# COVID-19 brought forth a paradigm shift, reluctantly....

*Clinical Infectious Diseases*

INVITED COMMENTARY



## It Is Time to Address Airborne Transmission of Coronavirus Disease 2019 (COVID-19)

Lidia Morawska<sup>1</sup> and Donald K. Milton<sup>2</sup>

<sup>1</sup>International Laboratory for Air Quality and Health, WHO Collaborating Centre, Queensland University of Technology, Brisbane, Australia, and <sup>2</sup>Institute for Applied Environmental Health, University of Maryland School of Public Health, College Park, Maryland, USA

Received: 12 November 2021 | Revised: 25 May 2022 | Accepted: 30 May 2022

DOI: 10.1111/ina.13070

REVIEW

WILEY

## What were the historical reasons for the resistance to recognizing airborne transmission during the COVID-19 pandemic?

Jose L. Jimenez<sup>1</sup> | Linsey C. Marr<sup>2</sup> | Katherine Randall<sup>3</sup> | Edward Thomas Ewing<sup>4</sup> | Zeynep Tufekci<sup>5</sup> | Trish Greenhalgh<sup>6</sup> | Raymond Tellier<sup>7</sup> | Julian W. Tang<sup>8</sup> | Yuguo Li<sup>9</sup> | Lidia Morawska<sup>10</sup> | Jonathan Mesiano-Crookston<sup>11</sup> | David Fisman<sup>12</sup> | Orla Hegarty<sup>13</sup> | Stephanie J. Dancer<sup>14</sup> | Philomena M. Bluyssen<sup>15</sup> | Giorgio Buonanno<sup>16</sup> | Marcel G. L. C. Loomans<sup>17</sup> | William P. Bahnfleth<sup>18</sup> | Maosheng Yao<sup>19</sup> | Chandra Sekhar<sup>20</sup> | Pawel Wargocki<sup>21</sup> | Arsen K. Melikov<sup>21</sup> | Kimberly A. Prather<sup>22</sup>

### WHO's departing chief scientist regrets errors in debate over whether SARS-CoV-2 spreads through air

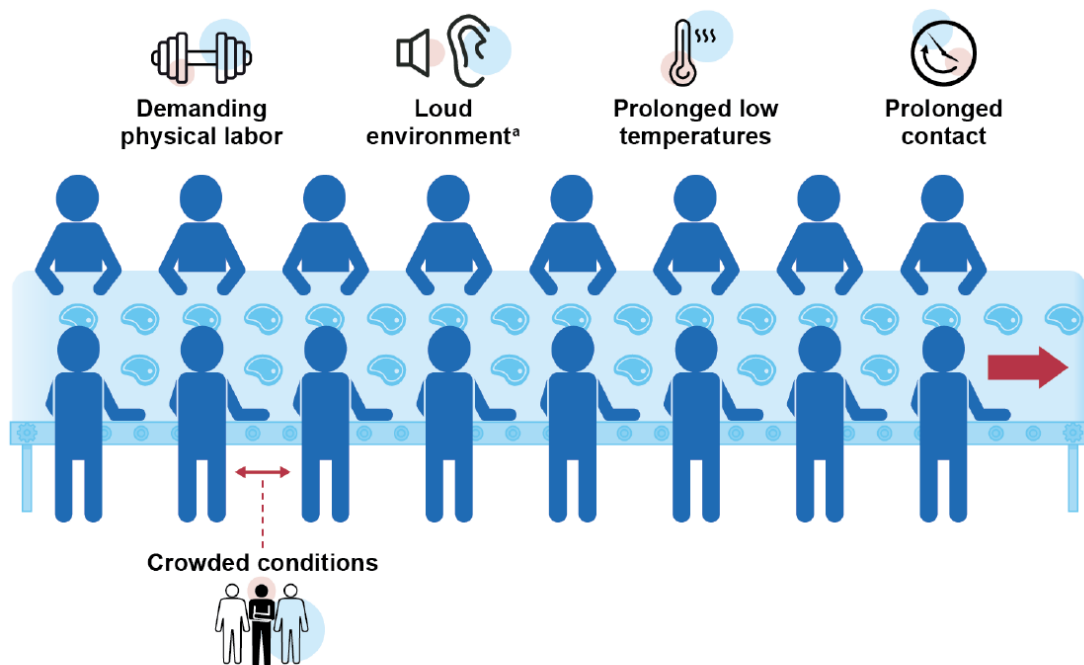
Soumya Swaminathan says the agency should have acknowledged aerosol transmission "much earlier" but is proud of work on vaccine equity

23 NOV 2022 • 2:45 PM • BY KAI KUPFERSCHMIDT



# COVID-19 brought forth a paradigm shift, reluctantly.... .... supported by epidemiological data

Figure 2: Conditions in Meat and Poultry Plants that Affect Workers' Risk of Contracting COVID-19



Source: GAO analysis of CDC documentation and academic research paper; GAO (icons). | GAO-23-105104



United States Government Accountability Office  
Report to Congressional Addressees

June 2023

## MEAT AND POULTRY WORKER SAFETY

OSHA Should  
Determine How to  
Address Persistent  
Hazards Exacerbated  
by COVID-19

# September 2022: USDA launches invitation-only Meat and Poultry Processing Research Initiative



- Priority Area 2: Worker Safety: “... modifications could include, but are not limited to ... sanitation strategies to mitigate communicable diseases (e.g., COVID-19)....”
- Two-piece design preferred over “all-in-one” visor:
  - minimizes additional weight on head
  - preserves existing choice for head protection
  - easy to add to normal PPE ensemble

## Funding:

 **USDA** National Institute of Food and Agriculture  
U.S. DEPARTMENT OF AGRICULTURE

## Prime:



## Partners:



**Northern Illinois University**



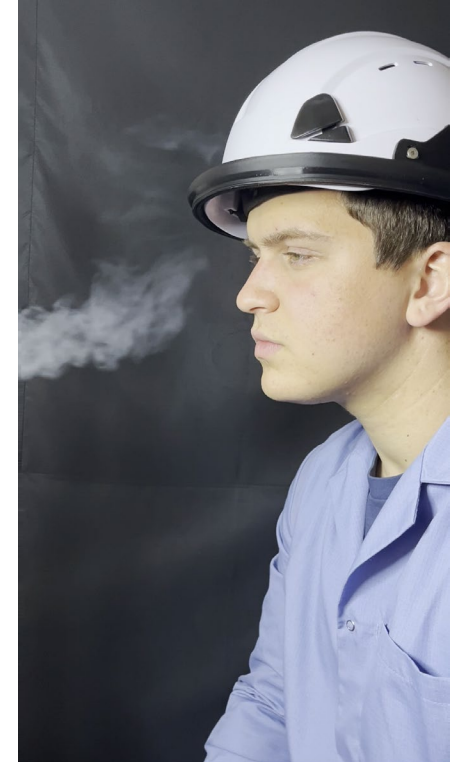
# Taza Aya's plasma-enabled wearable air curtain



- Current beta prototype in user validation testing at Michigan Turkey.
- Key features:
  - 3DP nozzle array attaches to existing hard hat
  - 9.5 lb hardshell backpack with ergonomic harness contains electro-mechanical components
  - > 7.5 hr battery life
- Key benefits:
  - No breathing resistance
  - No fogging of safety goggles / eyewear
  - Allows communication through facial expressions
  - Clearer spoken communication, especially for multilingual users

# Demonstrated Performance

- 99.8%** reduction in inhaled viral aerosols by the user  
(3<sup>rd</sup>-party testing)
- 95%** reduction in inhaled viral aerosols by **an unprotected bystander** (at 2 ACH)  
(3<sup>rd</sup>-party testing)
- > 90%** NTP inactivation of viral aerosols; up to 99.2% (Taza Aya test results)





TAZA AYA

## Current Status

- ✓ Prototype development completed 6 mos. early
- ✓ Validation of beta prototype ongoing at Michigan Turkey
- ✓ Seeking additional product validation sites





Contact us:



# Airborne transmission: Collective protection vs. PPE approaches

- Analogy: “cold flame”
- More common NTP uses:
  - surface treatment (surgical tools, Si wafer fabrication, accelerated seed germination)
  - batch liquids (PFAS remediation, plasma-activated water)
- What’s different for air disinfection?
  - msec exposure, not mins or hrs
  - aerosol dynamics, charged & uncharged
  - dilute concentrations can challenge detection limit of many analytical methods
  - disinfection effectiveness determined by microbiological assays (slow)

# Airborne virus inactivation via non-thermal plasma

- Analogy: “cold flame”
- More common NTP uses:
  - surface treatment (surgical tools, Si wafer fabrication, accelerated seed germination)
  - batch liquids (PFAS remediation, plasma-activated water)
- What’s different for air disinfection?
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