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2023 IUVA WORLD CONGRESS

Festival City, Dubai, U.A.E.

Next Generation PPE for Real-time Inactivation of Airborne Biological Threats, Part III: UV-C Powered Symmetrical Flow Disinfection (SFD) Device

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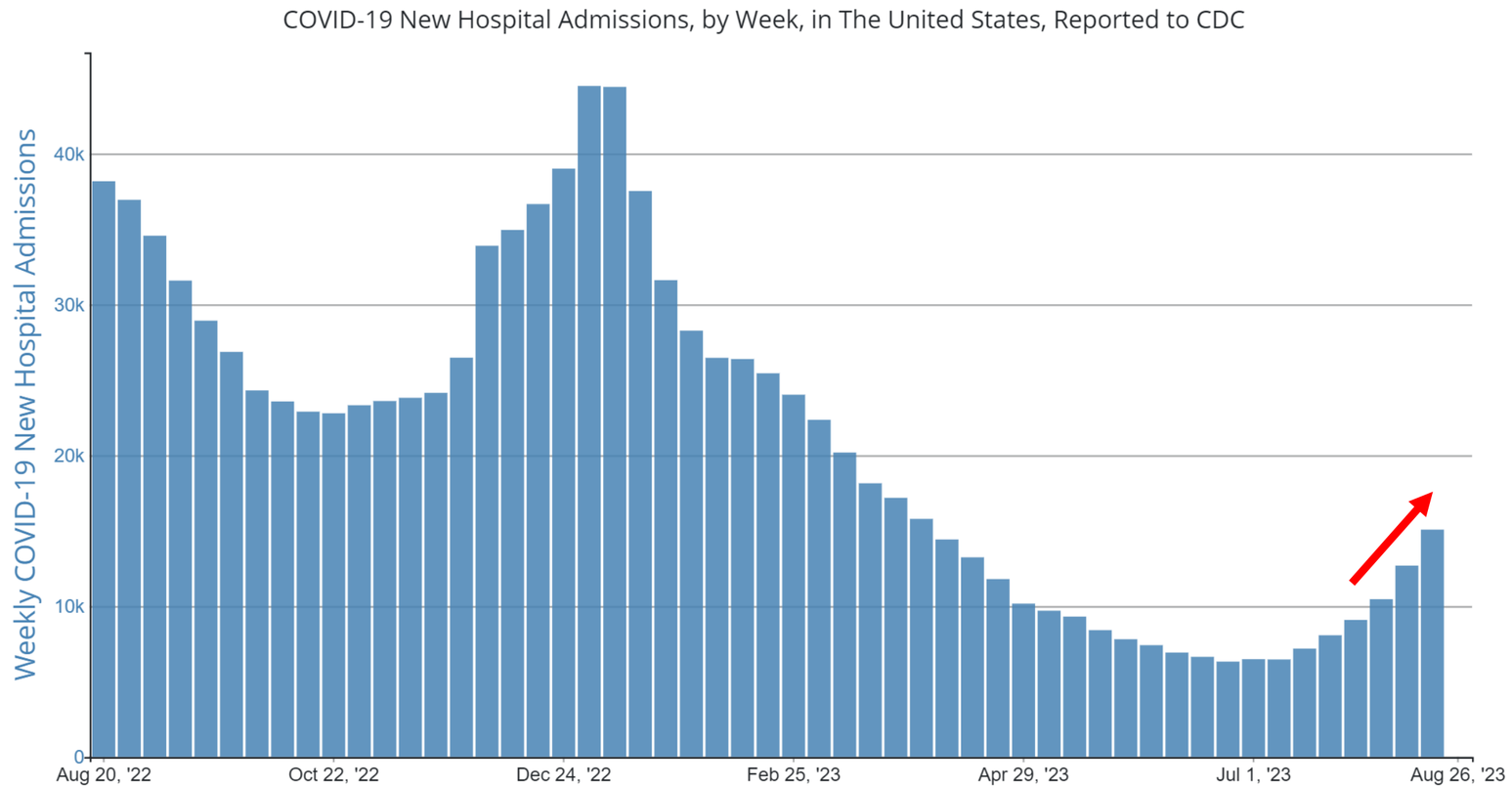
VP, Product Engineering

XCMR

The Problem | Airborne Biothreats

- Lessons of the pandemic
  - Airborne biothreats are a global perennial challenge
  - PPE is critical, but outdated.
  - Challenge/opportunity for new innovative solutions.



CNN

"It may be time to break out the masks against Covid, some experts say"

8/23/23

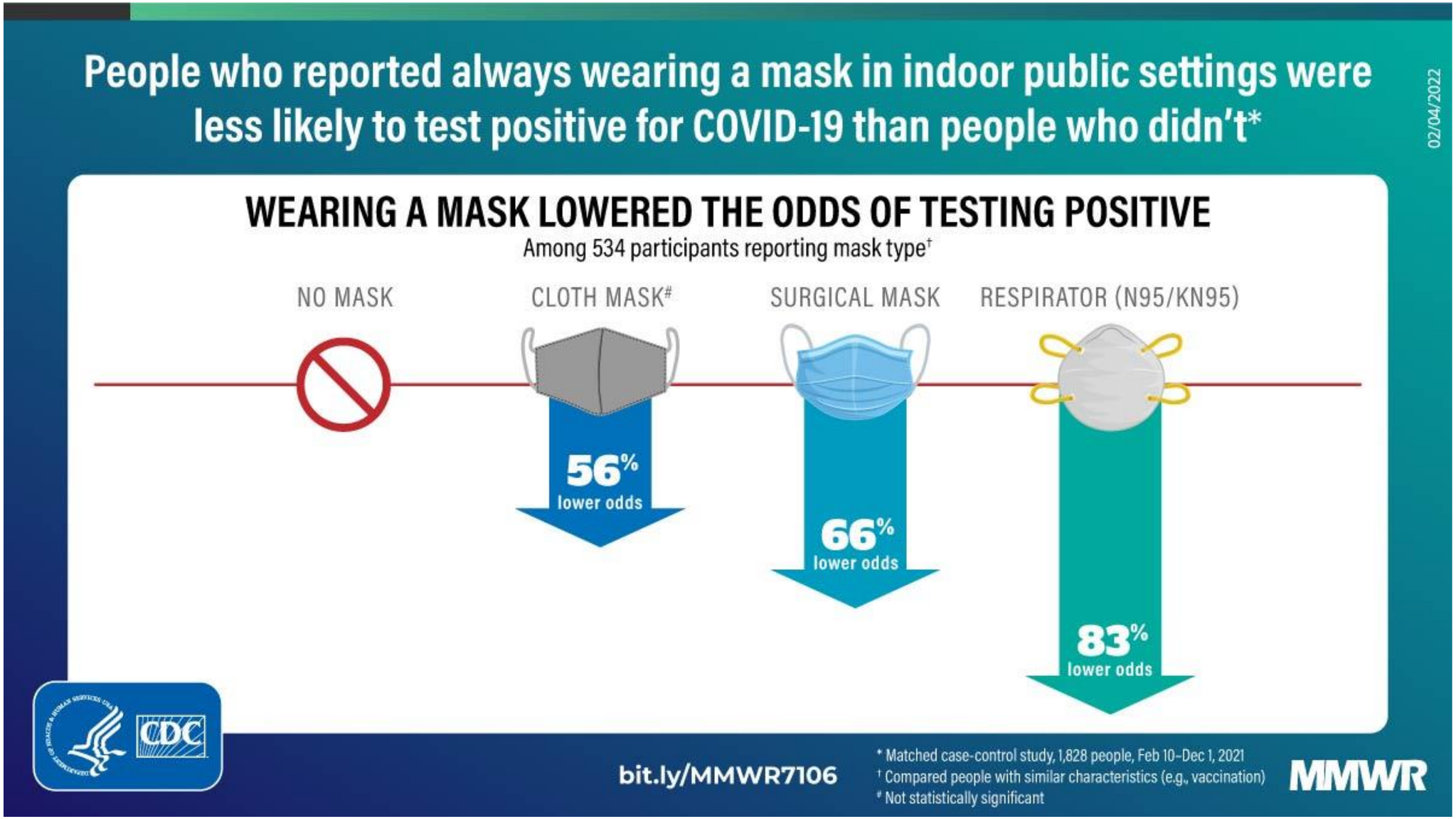
The New York Times
Expect the World®

"Not Over Yet: Late-Summer Covid Wave Brings Warning of More to Come"

8/28/23

Centers for Disease Control and Prevention. COVID Data Tracker. Atlanta, GA: U.S. Department of Health and Human Services, CDC; 2023, August 31. https://covid.cdc.gov/covid-data-tracker

Comparing Respiratory PPE



XCMR’s mission is to transform and modernize biodefense efforts, specifically against airborne biothreats. Leading with multidisciplinary science and business team focusing in advanced photochemistry reactor theory, ultraviolet (UV) radiation and disinfection processes, fluence rate fields and CFD modeling.

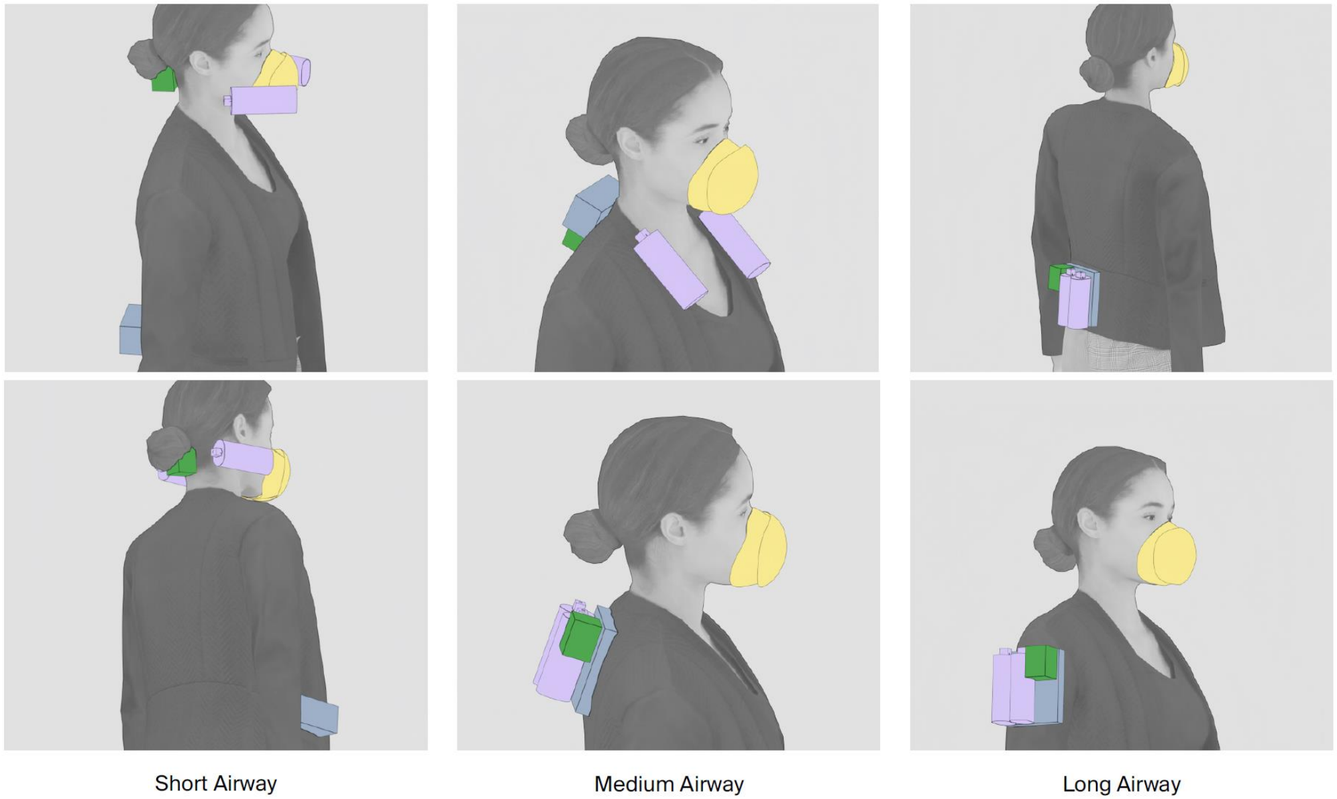
ADVANCED NEXT GENERATION PPE

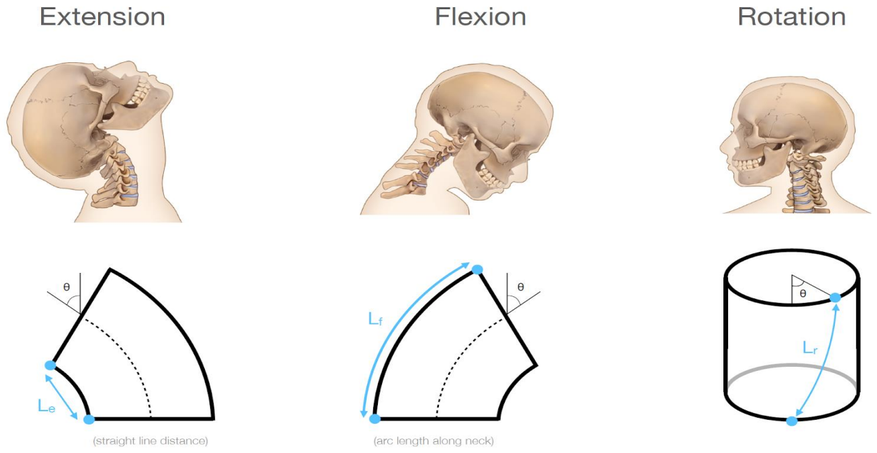
Respiratory protection from infectious diseases and infection control for viruses

Symmetrical Flow Concept

Biomechanics and Ergonomics

- Core components
  - Mask, Reactors, Battery, Electronics
- Body placement on Airway Length
  - 3 Airway lengths
- Anthropometric Measurements
  - Tube Length/RoM



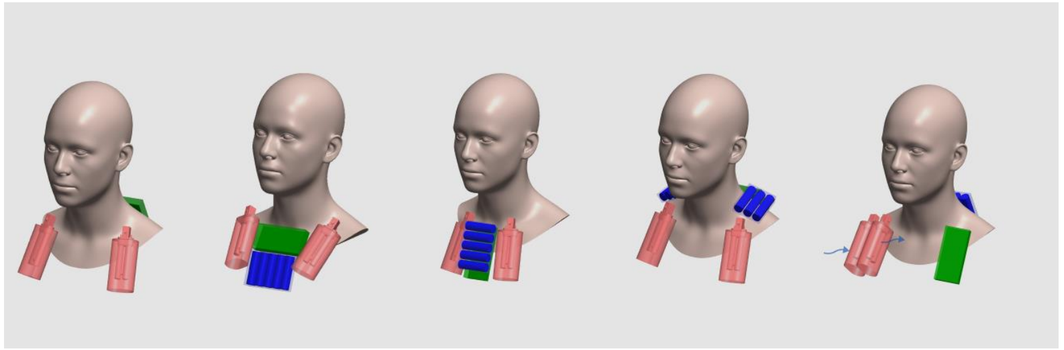


$$L_e = 2(L_n/\theta - R_n)\sin(\theta/2)$$

$$L_f = L_n + \theta R_n$$

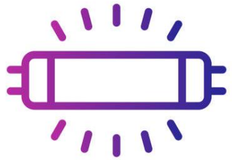
$$L_r = \sqrt{L_n^2 + (R_n\theta)^2}$$

L_n = neck length
R_n = neck radius
θ = angle of articulation (in radians)

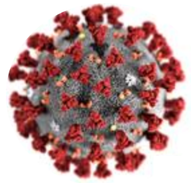


COMPONENT SELECTION | UVC EMITTER

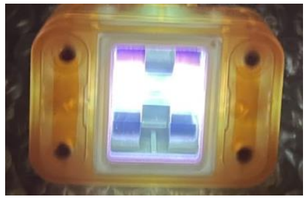
- Input Parameters
  - Targets = SARS-CoV-2
  - LRV ≥ 1.5 N95 (95 % filtration)
  - Volume = 100 mL
  - Peak Flow Rate = 90 L/min
  - Min run time = 3 hours
- UVC Source selection
  - Benchmark 56 Emitters
  - Ideal Reactor (Ray Tracing/CFD)



UV LIGHT DISINFECTION



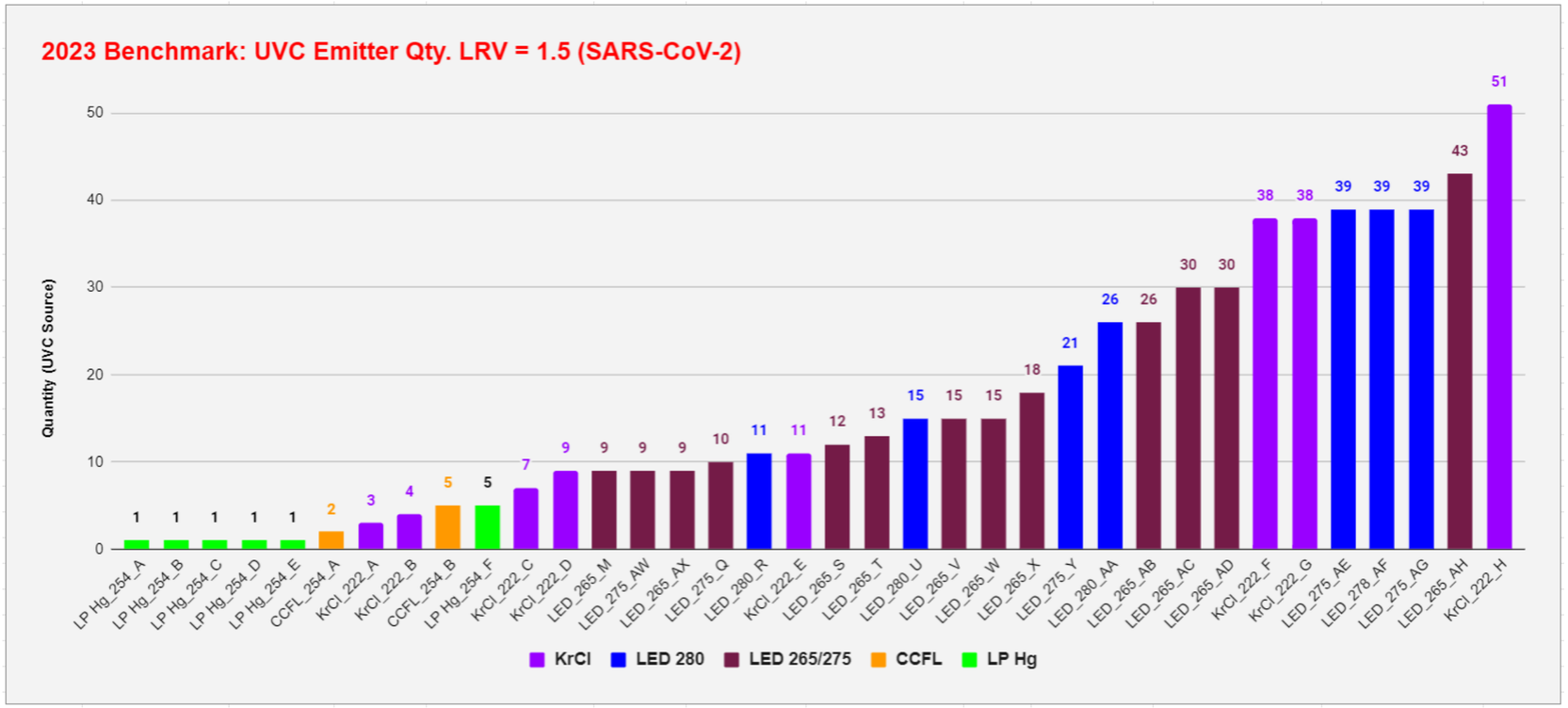
Lp Hg Lamp

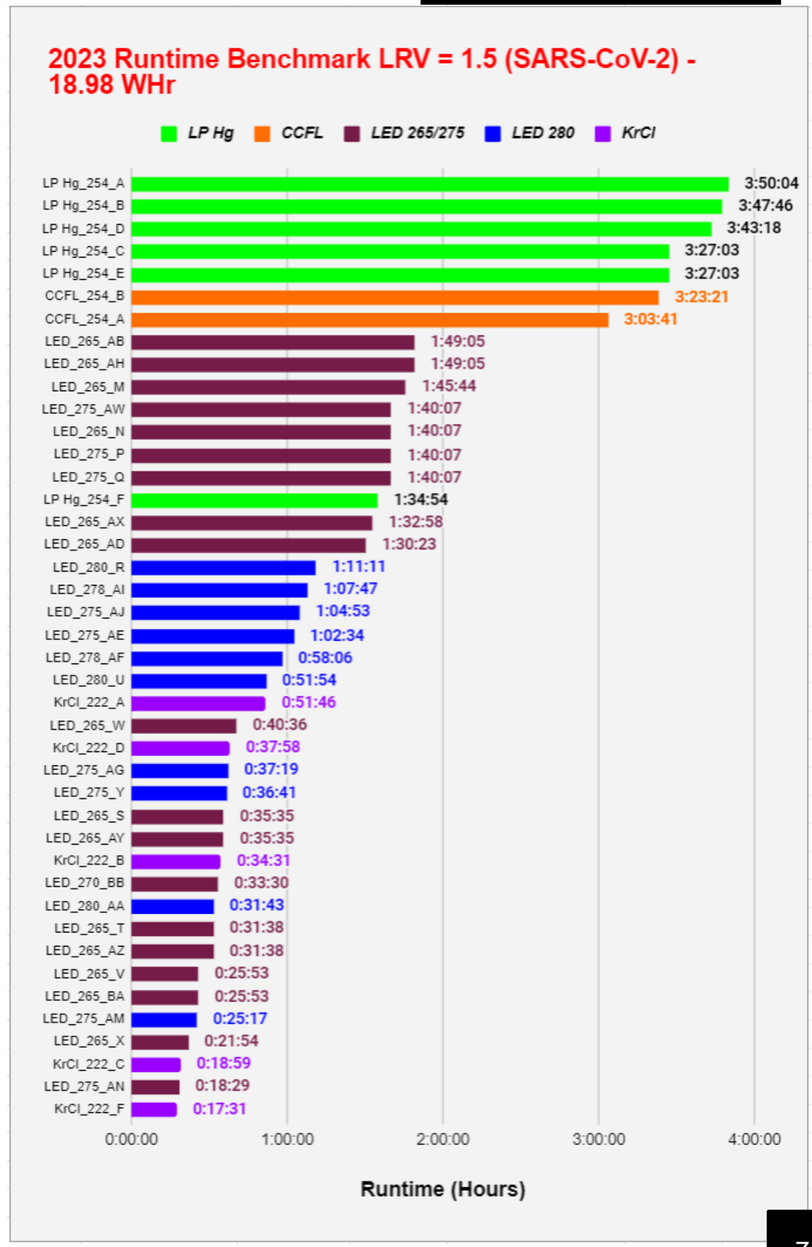


KrCl Excimer

UVC LED

CCFL

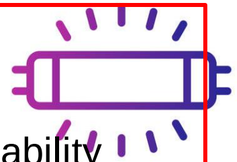


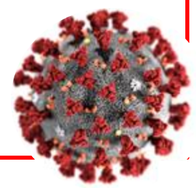


Simulation data based on SARS-CoV-2 UV Inactivation(Ma, Ben, et al.) https://doi.org/10.1128/aem.01532-21.

COMPONENT SELECTION | UVC EMITTER

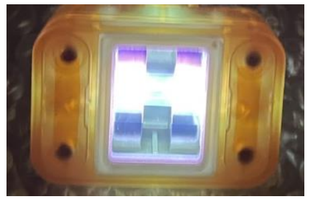
- Input Parameters
  - Selection
    - Targets = SARS-CoV-2
      - **Low Pressure Mercury Lamp**
    - LRV ≥ 1.5 N95 (95 % filtration)
      - (+) Output, Cost, WPE, Scalability
    - Volume = 100 mL
      - (-) Durability, Size, Control Capability
    - Peak Flow Rate = 90 L/min
  - Future
    - Min run time = 3 hours
      - **LEDs!**
- UVC Source selection
  - Benchmark 56 Emitters
  - Ideal Reactor (Ray Tracing/CFD)





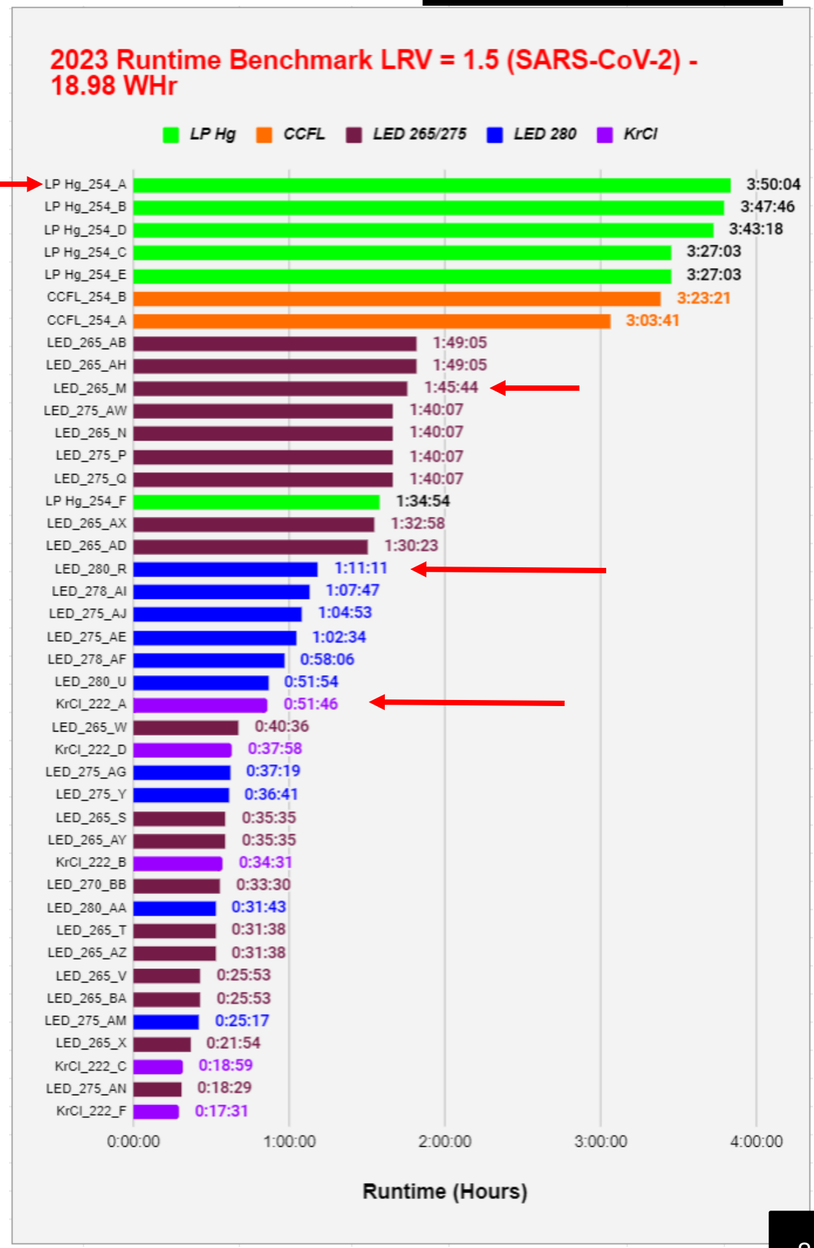
Lp Hg Lamp

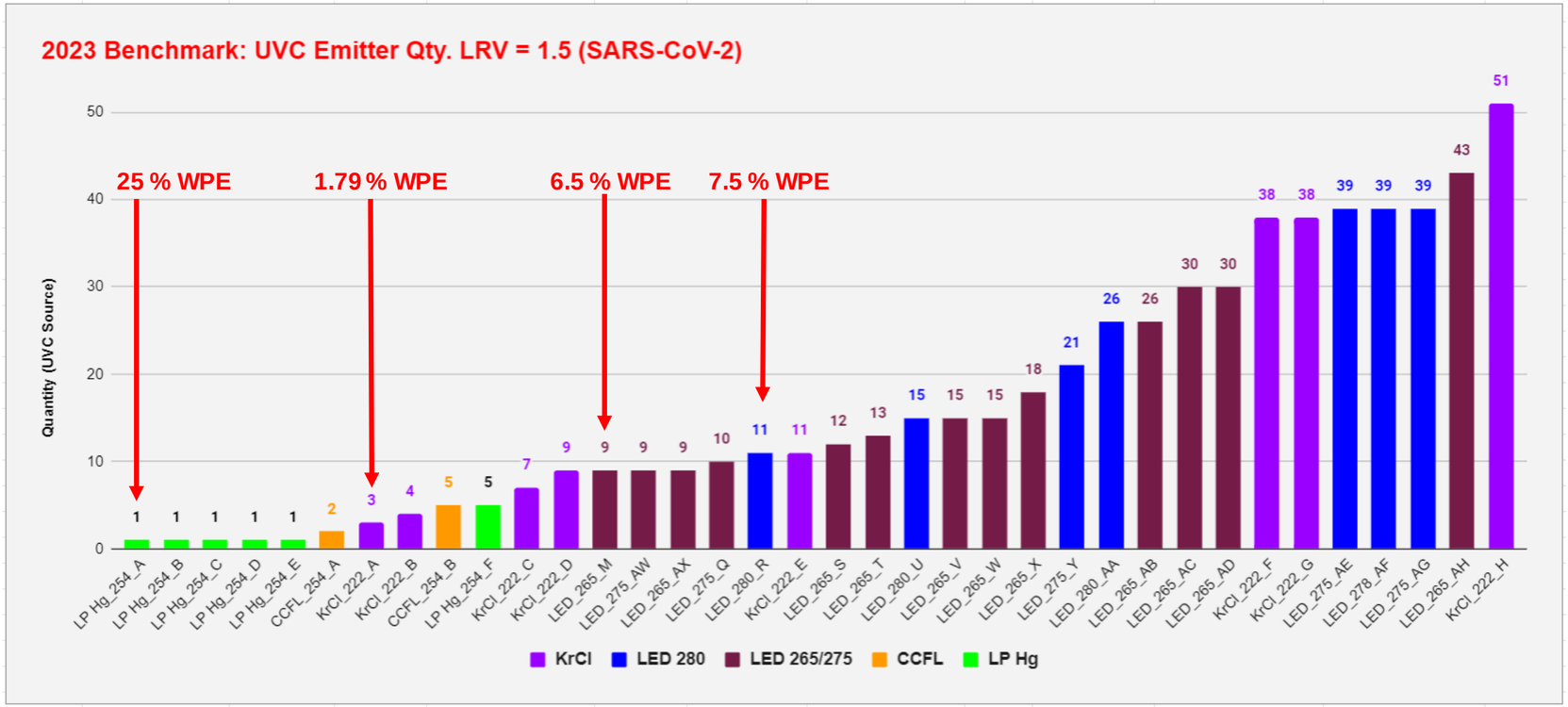
UVC LED



KrCl Excimer

CCFL

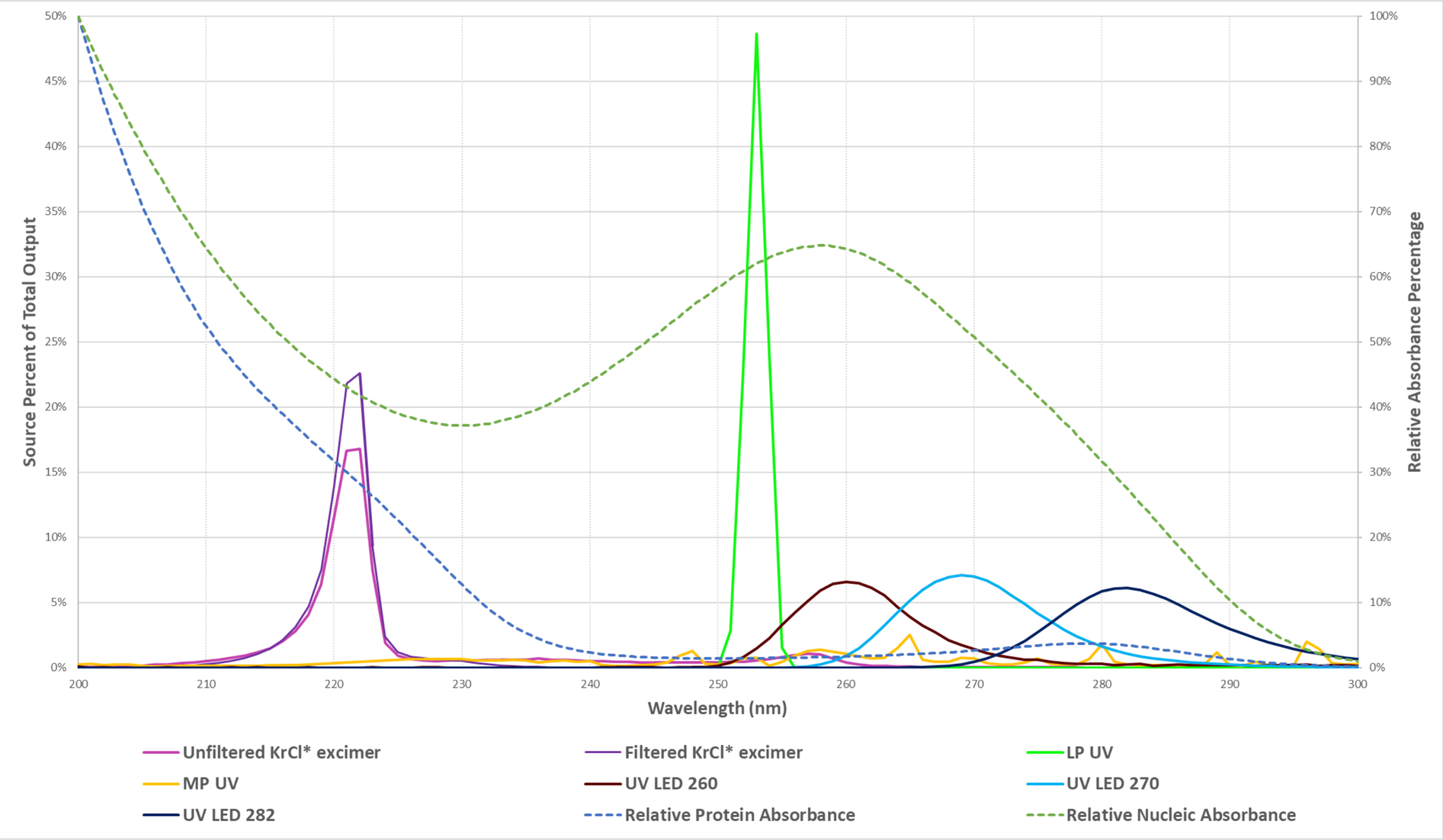




Simulation data based on SARS-CoV-2 UV Inactivation(Ma, Ben, et al.) https://doi.org/10.1128/aem.01532-21.

COMPONENT SELECTION | UVC EMITTER

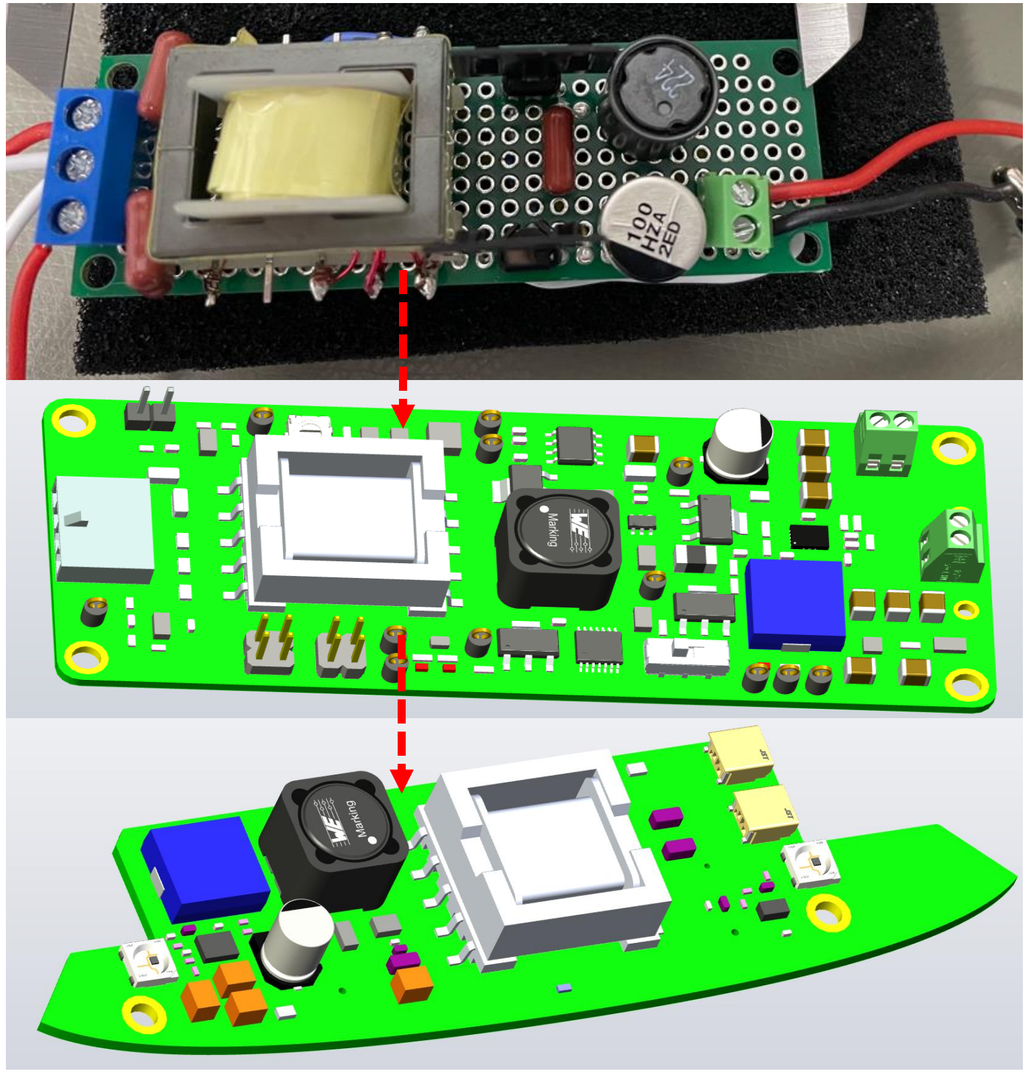
- Importance of Wavelength and HWM
- LEDs in particular

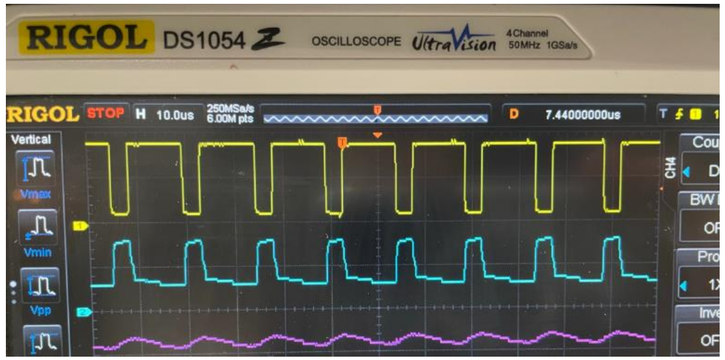


Source: https://doi.org/10.1128/aem.01532-21.

Miniature Light Engine

- Custom lamp driver
- Low voltage Input (3.7V)
- Sinusoidal wave-shape, η_e > 90 %
- Dual lamp control
- Dynamic lamp intensity Adj.
  - Smooth / continuous
- Fault protection/monitoring



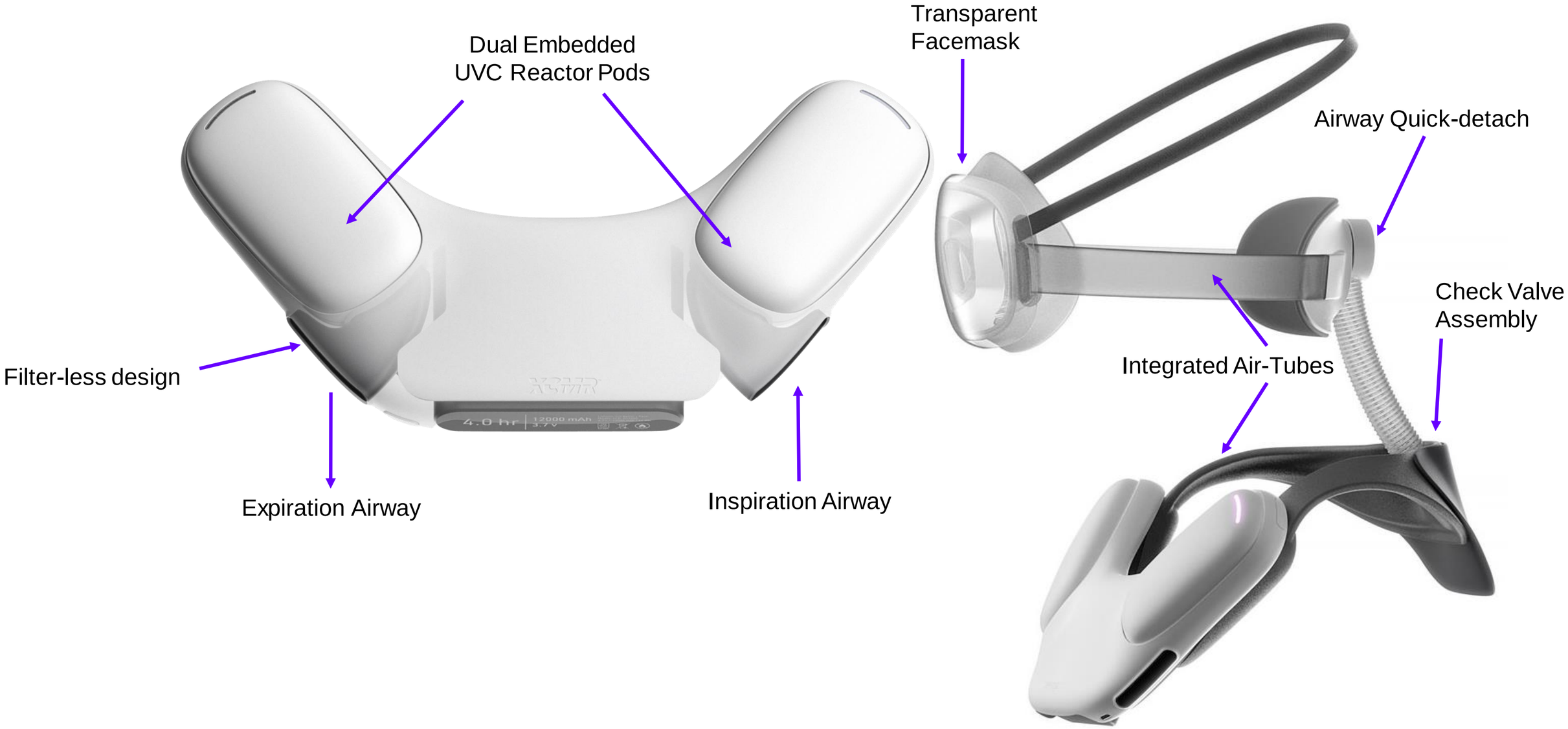


SYMMETRICAL FLOW DISINFECTION (SFD)

- Safe
- Re-usable
- Modular
- Enhanced Personal Protection
- Comfortable
- Adaptable
- Helps Prevent Transmission
- Portable
- Reliable

- First Responders
- Healthcare Workers
- ICP Patients
- Government Employees
- Military

Design Overview



DESIGN ARCHITECTURE | AIRFLOW

ambient air

disinfected air

exhaled air

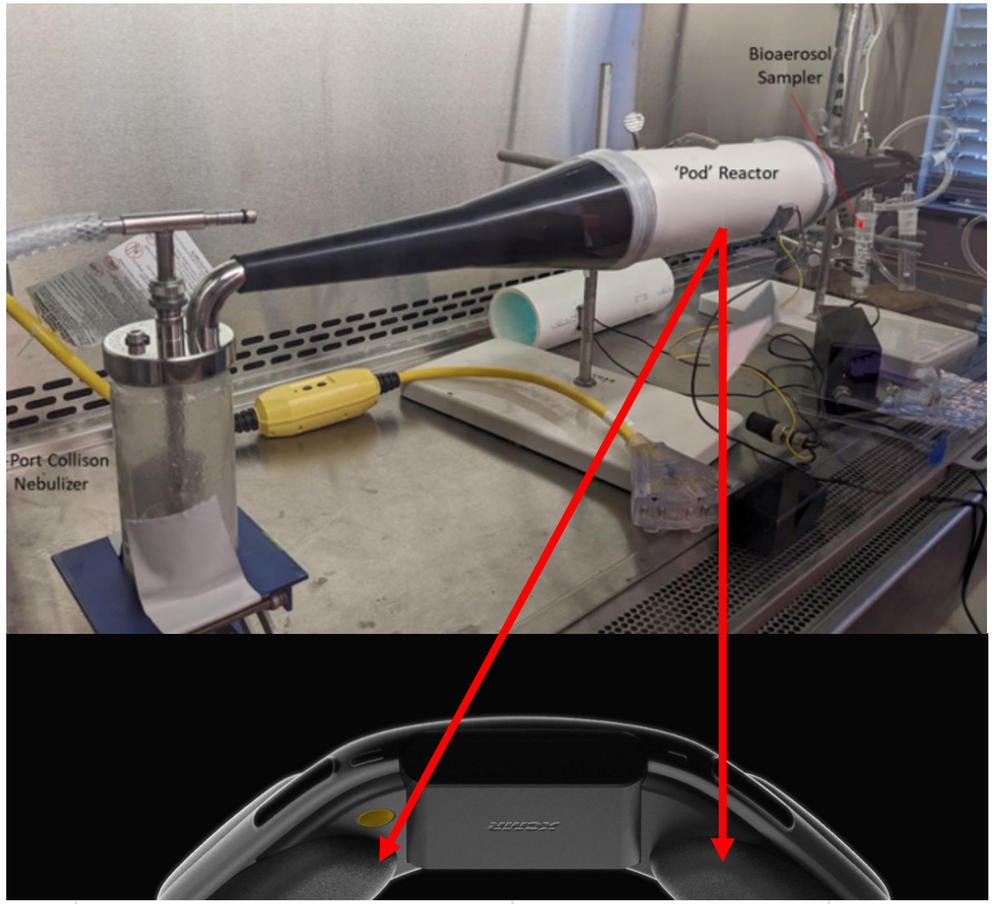
System Architecture

- Modular Reactor Pod
  - Diversity of UVC Emitters
  - Upgradable
  - Wavelength-tuned solution
- Hot-swappable Battery
- Bimodal Protection
  - 1 or 2 way flow-switch
- Feedback
  - Visual
  - Haptic
  - Breath sensing
- Connectivity
  - Bluetooth/Wi-Fi/Mesh

Technical Details

- Biological Testing
  - Surrogate virus (aerosolized T1 phage)
  - **Reactor Pod Experiment**
  - **Mannequin Experiment**
- Expected results

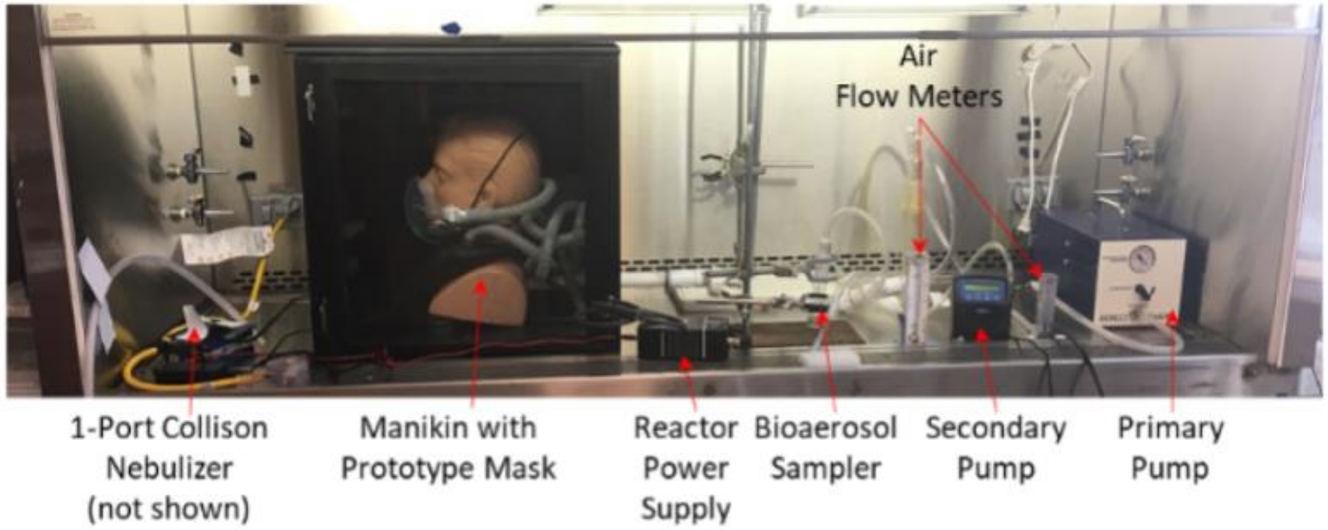
	Symmetrical	Unidirectional
Min. UV Dose	2.4 mJ/cm^2	4.8 mJ/cm^2
Flow Rate	90 L/min (inhale/exhale)	90 L/min (inhale)
Weight	3 lbs	
Runtime	4 hours	
Recharge	1.5 hours	



	Pathogen	SARS-CoV-2			
	Activity	**At-Rest**	**Sitting / Working**	**Walking**	**Moderate Exercise**
	Peak Flow	40	75	105	150
Symmetrical	Min. Dose	5.4	2.8	2	1.4
	Est. LRV	>4	2.3	1.67	1.2
	% Reduction	99.99+	99.5	97.88	93.76
Unidirectional	Min. Dose	10.8	5.7	4.1	2.8
	Est. LRV	>6	>4	3.2	2.3
	% Reduction	99.9999+	99.99+	99.9+	99.5

Future Directions

- Standardization
  - Intrinsic kinetics of inactivation for bio-aerosols
  - Human respiratory flow rates
- Laboratory Testing
  - Live virus (BSL3)
- Regulatory Framework
- Develop consensus standards/regulations
    - UV-C Efficacy
    - Proactive cooperation
  - Evidence-based, scientifically validated
- Field Testing
- Improved Reactor Pod
  - Expand Emitter types and Pathogen targets
  - Scalability beyond PPE



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Project Sponsors and Partners

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University of Colorado **Boulder**

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BIODEFENSE SOLUTIONS

Thank you!

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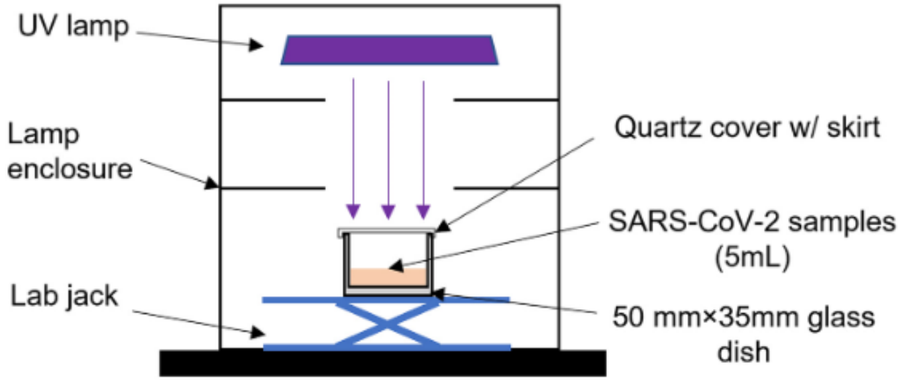
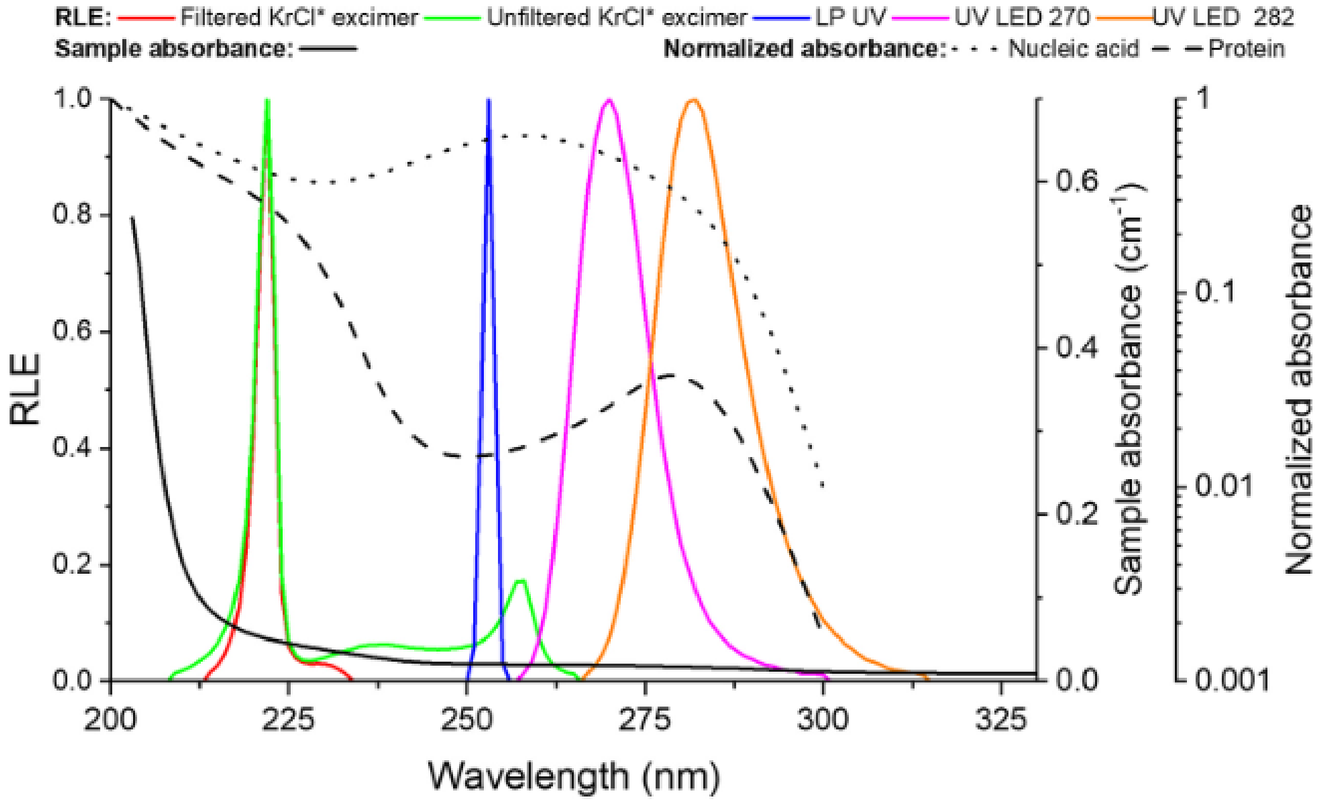
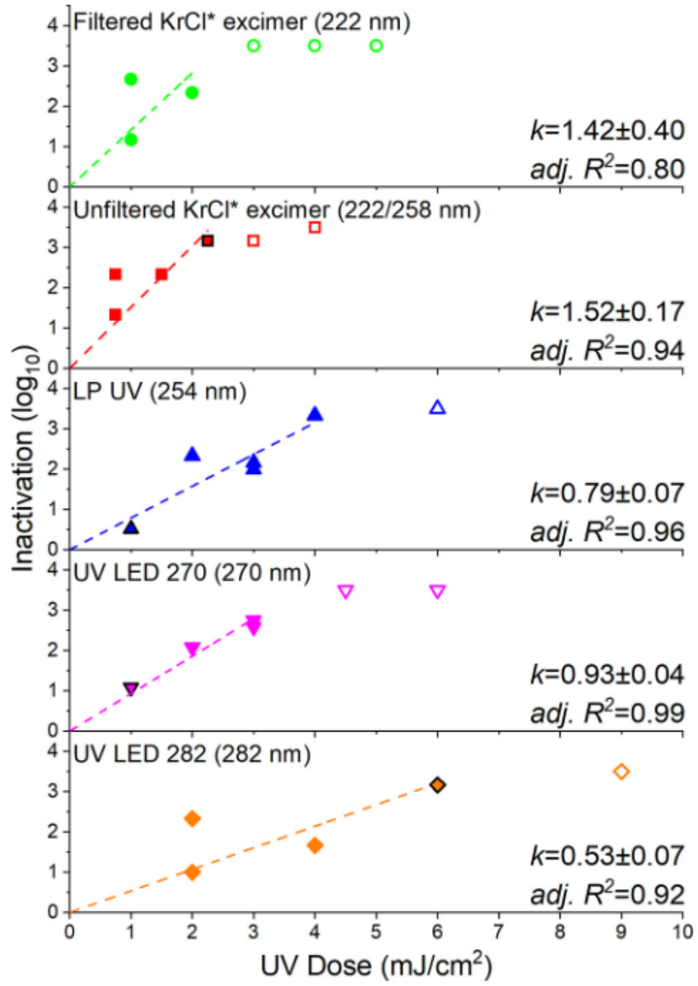
Supplemental Information

Appendix A

- Dose Response/Spectrum Analysis

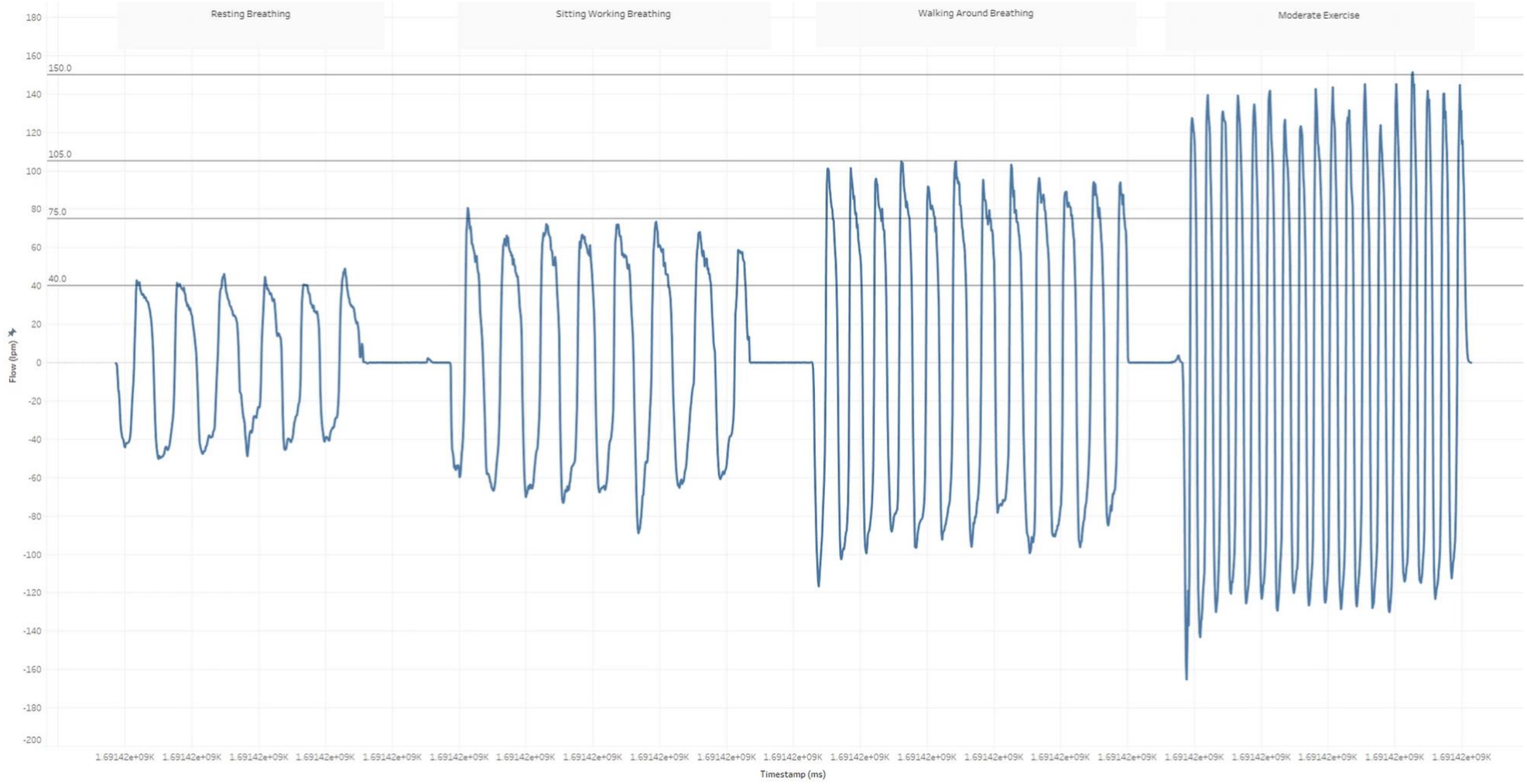






Appendix B

- Breathing Measurements



Measurements recorded from XCMR using SFM3300-AW on healthy adult male 6’3” middle aged (90th percentile)