XCMR™
BIODEFENSE SOLUTIONS

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Human Safe, Near-Field Infection Protection (NIP)™ for Continuous Pathogen Inactivation in Air and on Surfaces

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Infectious Disease Preparedness

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- Situation
  - Airborne pathogens threaten global health and economic security
  - COVID-19 has restricted interpersonal interactions
  - Health guidelines have been met with resistance
- Complication
  - Current PPE uses outdated technology and control of airborne pathogens varies
  - Demand for PPE resulted in short supply, exorbitant costs, and solid waste disposal issues
- Resolution
  - **Near-field Infection Protection (NIP):** Far UV-C protection for an individual's personal space
  - Incorporation of Far UV-C (222 nm) into wearable/portable devices to rapidly inactivate pathogens in air and on surfaces
  - Provide a continuous 'invisible' bubble of clean air around a user

Photo Credit (middle): Brian Yurasits; Photo Credit (bottom): Staff Sgt. Evelyn Chavez

Commercially Available Far UV-C Sources: KrCl* Lamps

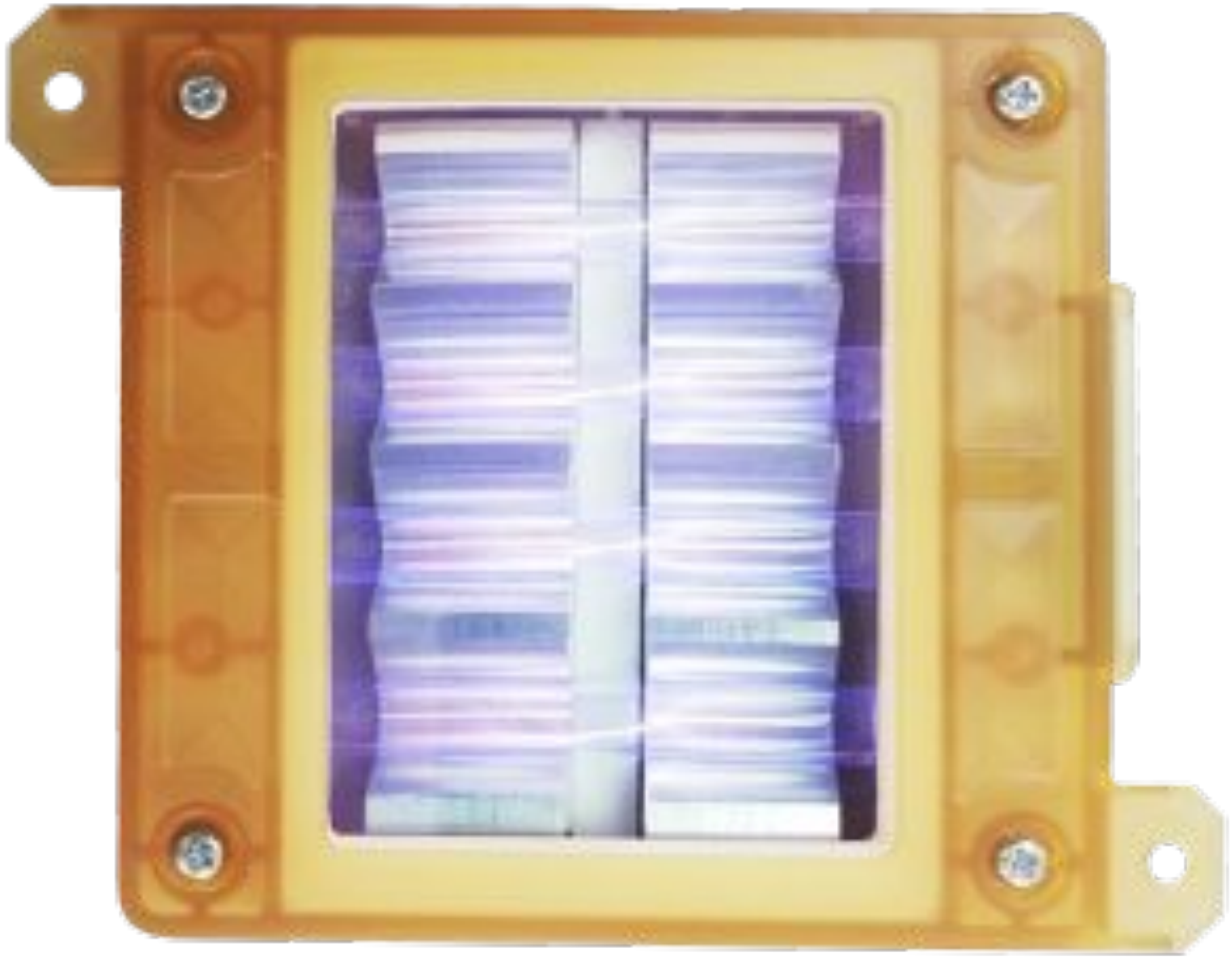

Image from www.ushio.com

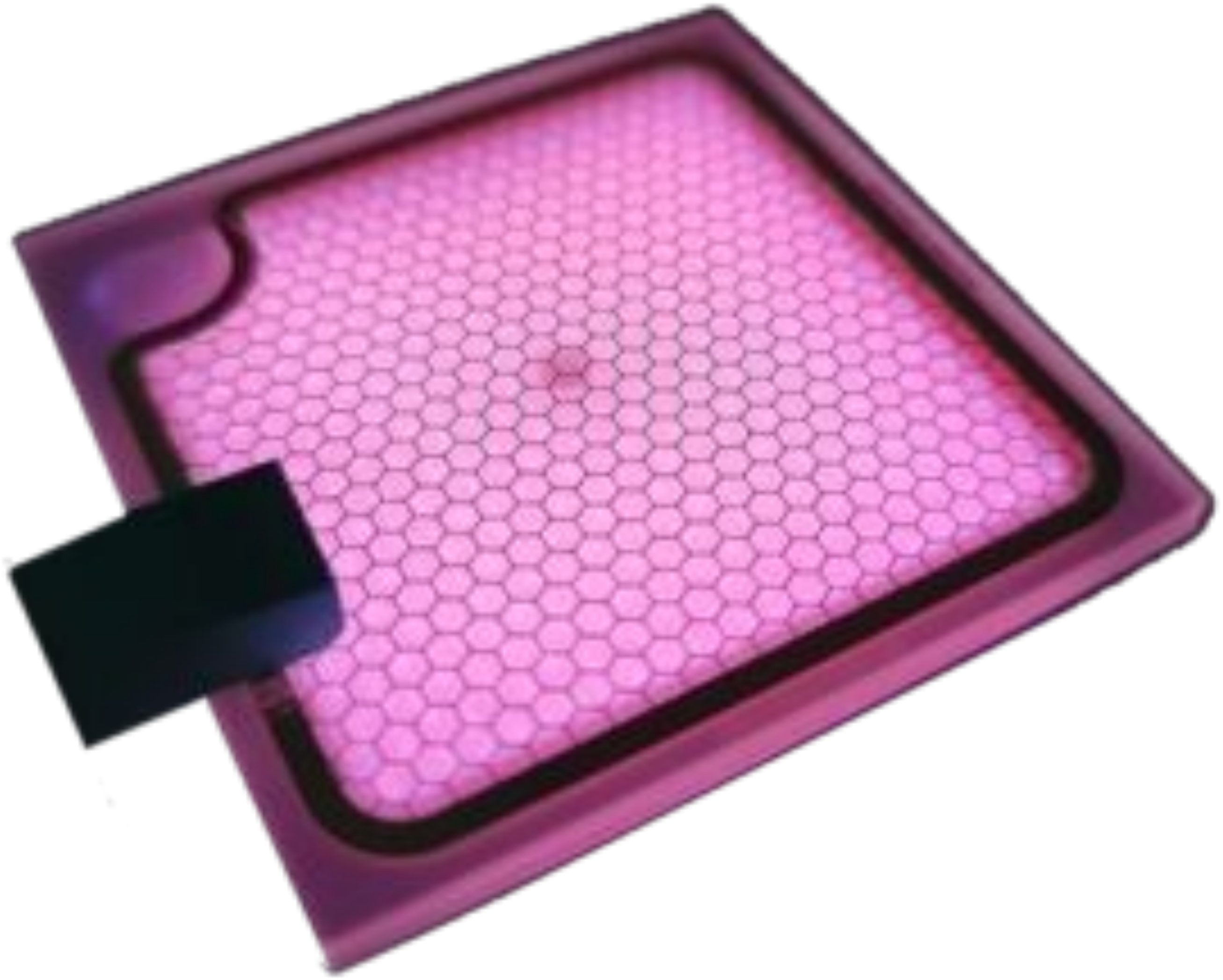

Image from www.edenpark.com

The Science: UV Radiation - Nomenclature

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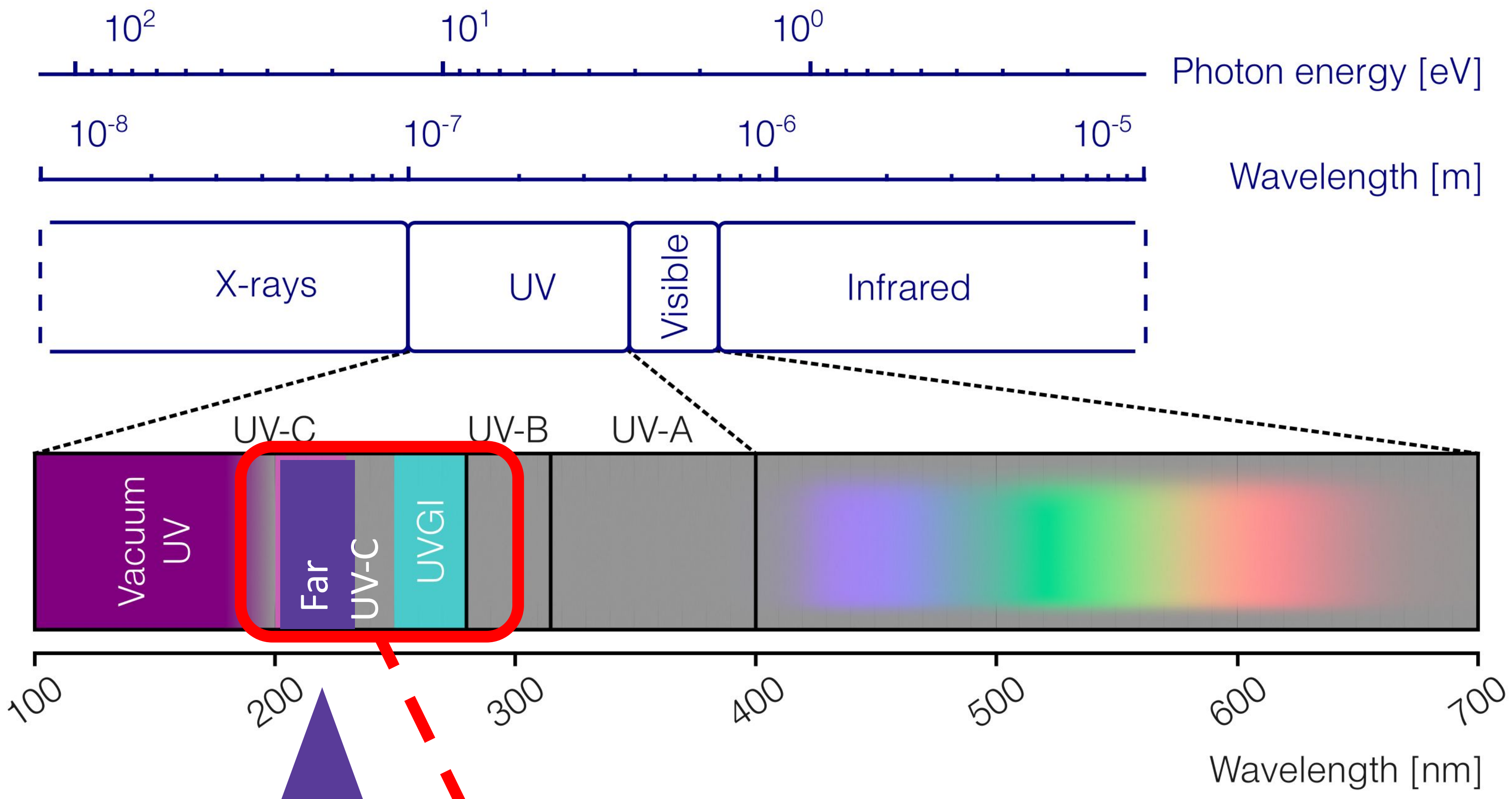
IUPAC

- UV: 100-400 nm
- UV-A: 315-400 nm
- UV-B: 280-315 nm
- UV-C: 200-280 nm
- Vacuum UV: 100-200 nm



Visible spectrum render from https://commons.wikimedia.org/wiki/File:Rendered_Spectrum.png
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Far UV-C: $200\ nm \lesssim \lambda \lesssim 230\ nm$

- Not a formal definition; description of a wavelength range
- Effective for disinfection
- Minimal potential for damage to mammalian tissues (skin, eyes)
- Possible 'game-changing' technology

Germicidal UV: $200\ nm \lesssim \lambda \lesssim 320\ nm$

- Photochemical damage to DNA, RNA
- Protein damage ($\lambda \lesssim 240\ nm$)

Image from: *Far UV-C Radiation: Current State-of-Knowledge* IUVA White Paper, https://iuva.org/resources/covid-19/Far%20UV-C%20Radiation-%20Current%20State-of%20Knowledge.pdf

UV Penetration Into Skin, Eye Tissues

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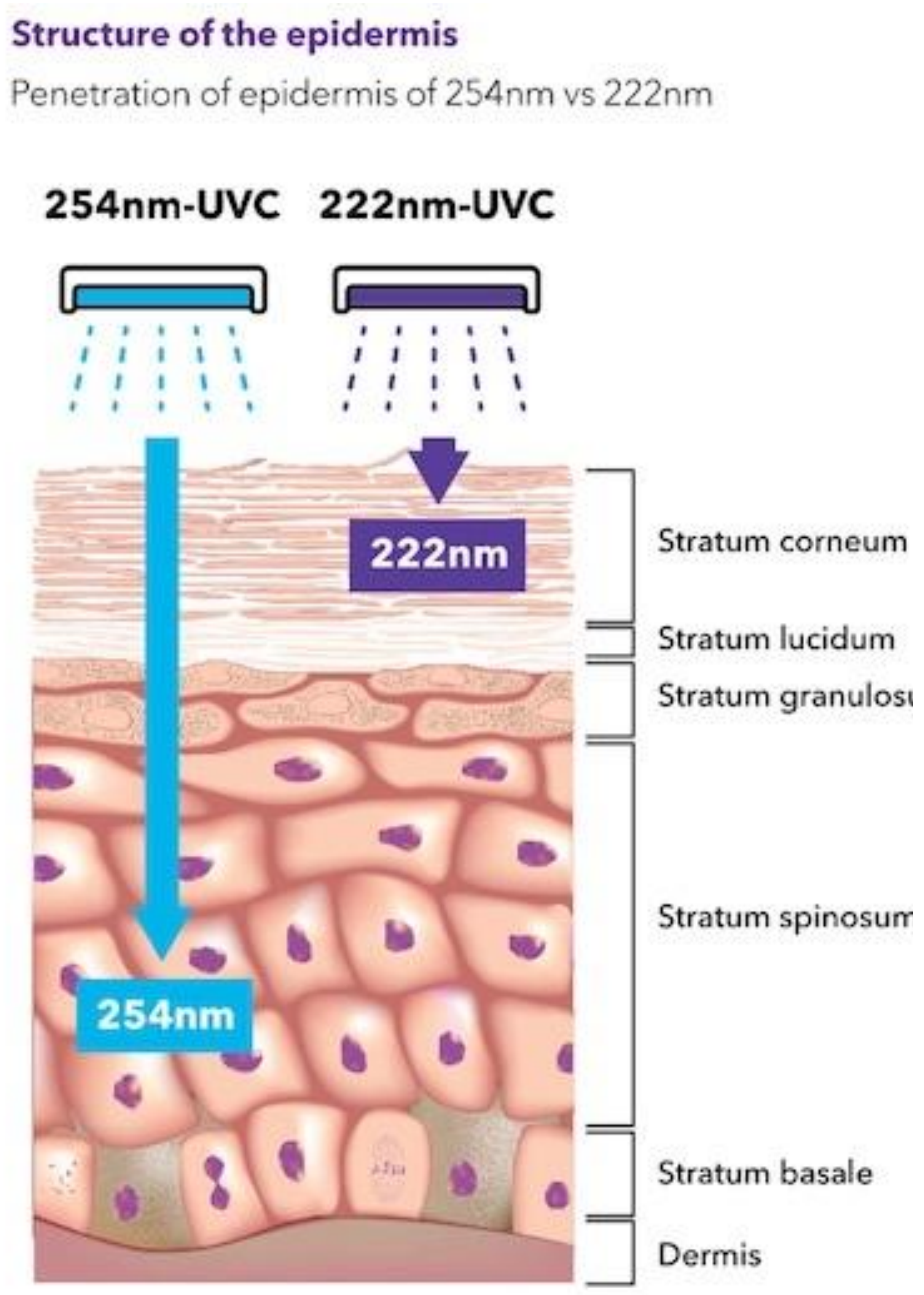
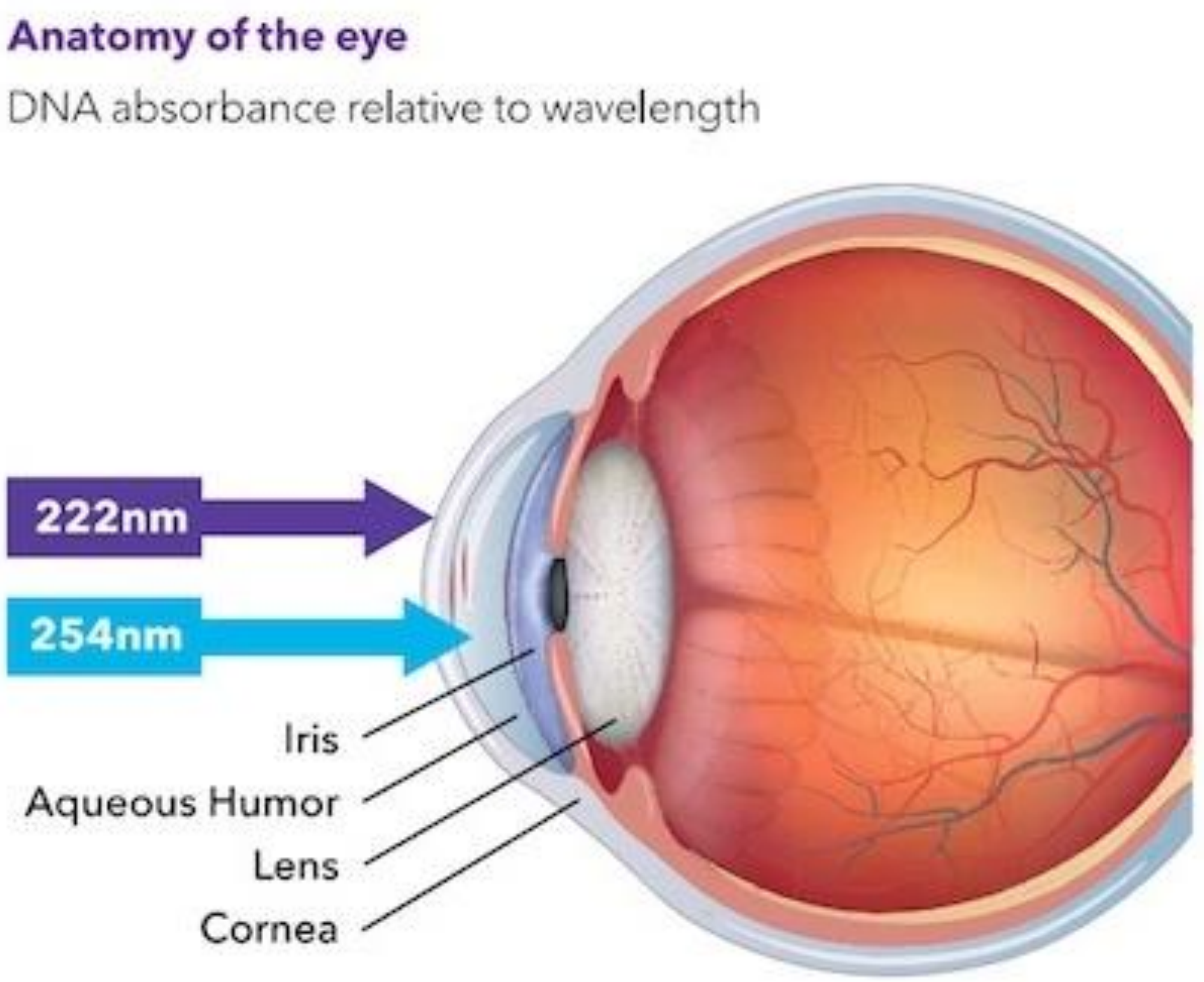




Source: https://blooloop.com/technology/in-depth/far-uvc-technology-attractions-covid-19/

UV-C Exposure Limits (TLVs)

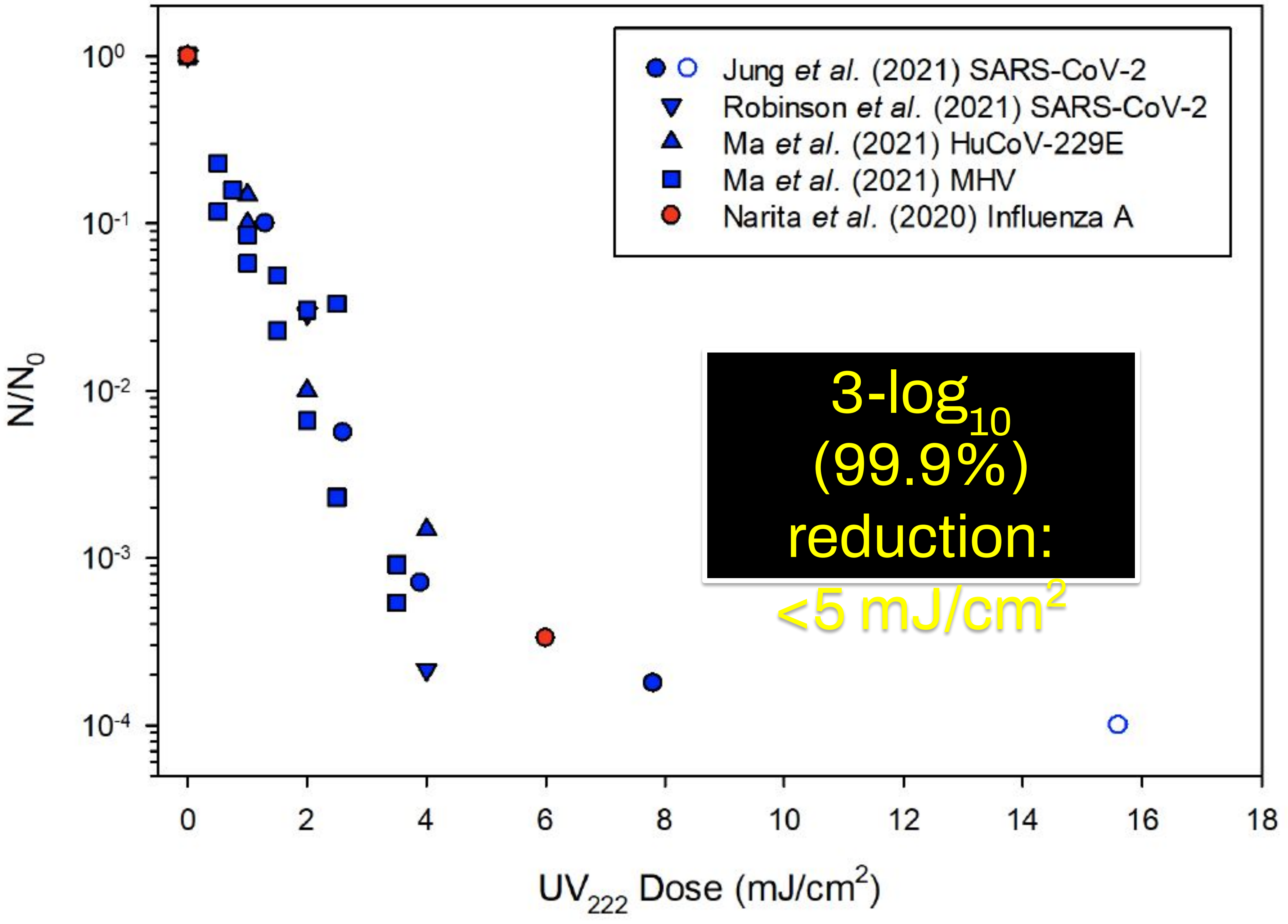
8-hr Exposure Limits (λ = 222 nm)

Current Guidance = 23 mJ/cm^2

ACGIH Proposal (Eyes) = 161 mJ/cm^2 **ACGIH Proposal (Skin) = 479 mJ/cm^2**

Output Spectra: KrCl* Lamps (Optically Filtered)

UV 222 nm Excimer Lamp Virus Disinfection



UV Dose = UV fluence rate x time of exposure

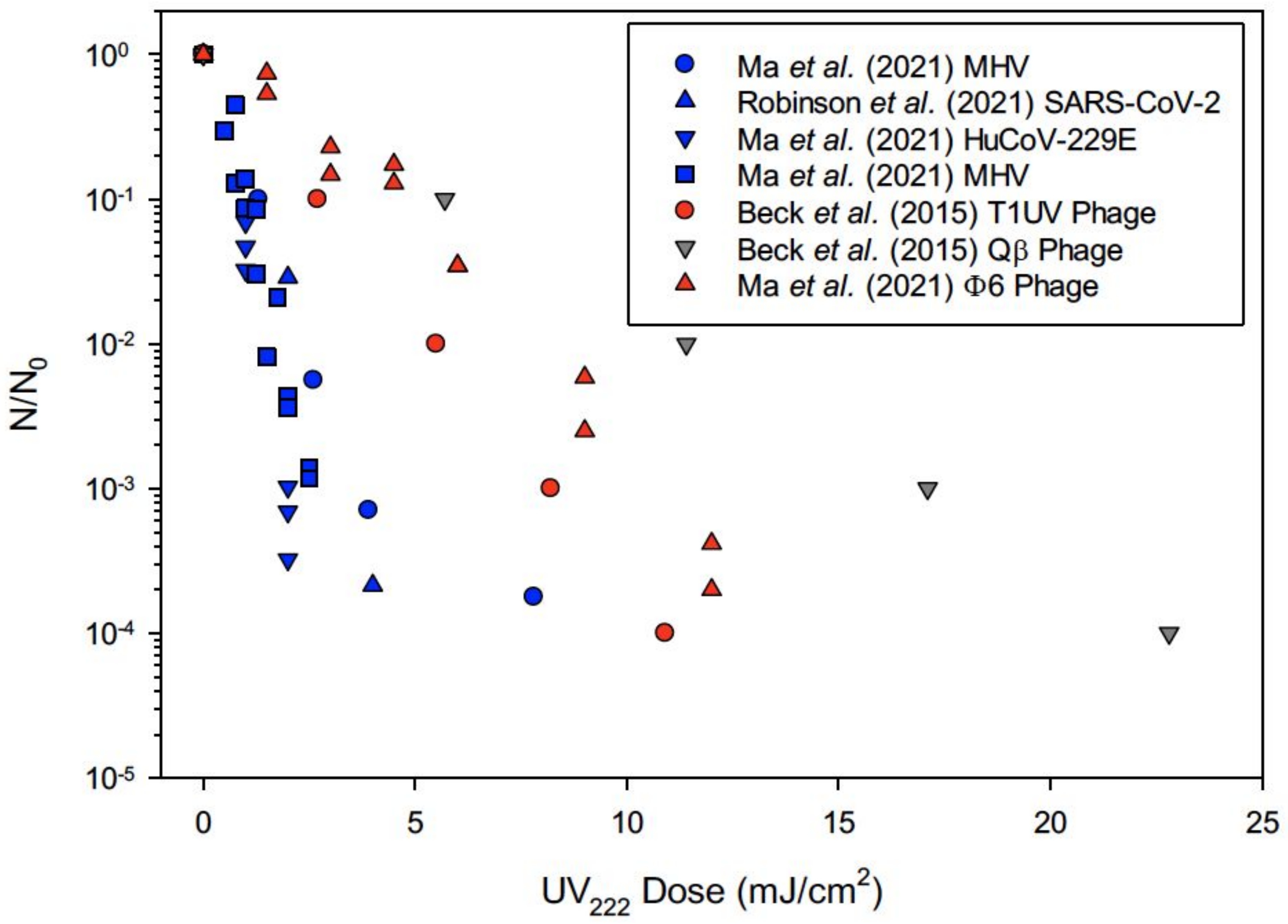
Respiratory viruses including

- SARS-CoV-2
- HuCoV-229E
- Influenza A

✔ Require very low UV doses

✔ All are among the most sensitive pathogens to UV

UV 222 nm Surrogates for Viral Pathogens



Pathogenic virus surrogates:

- T1 and T1UV phage
- Φ6 phage
- Qβ phage
- MHV (mouse virus)

✔ Similar linear behavior

✔ All are conservative for SARS-CoV-2

Phages infect bacteria, not human tissues

Modeling and System Simulations to inform UV performance and Design optimization

Numerical simulations provide a platform to investigate ‘What-if’ scenarios.
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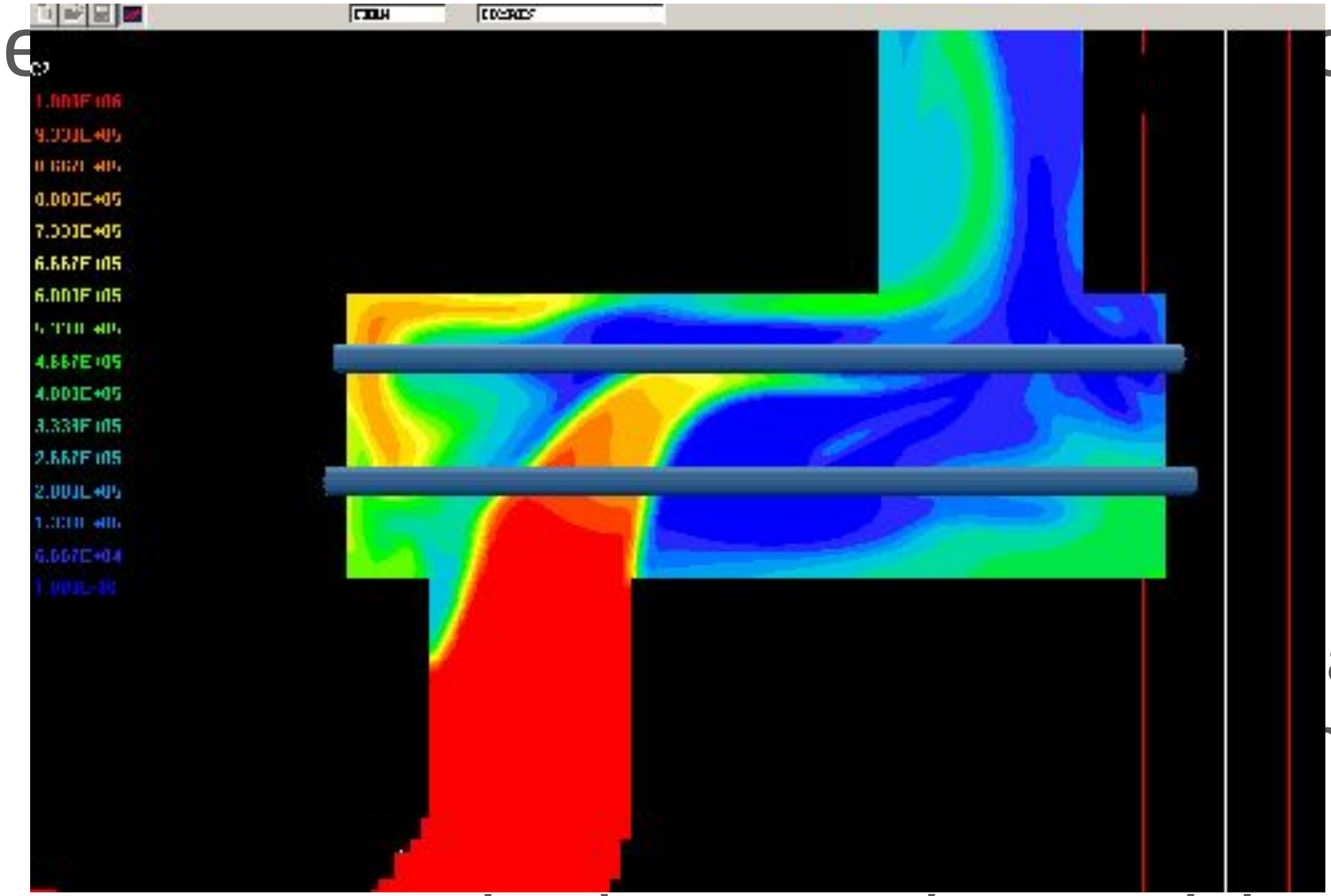

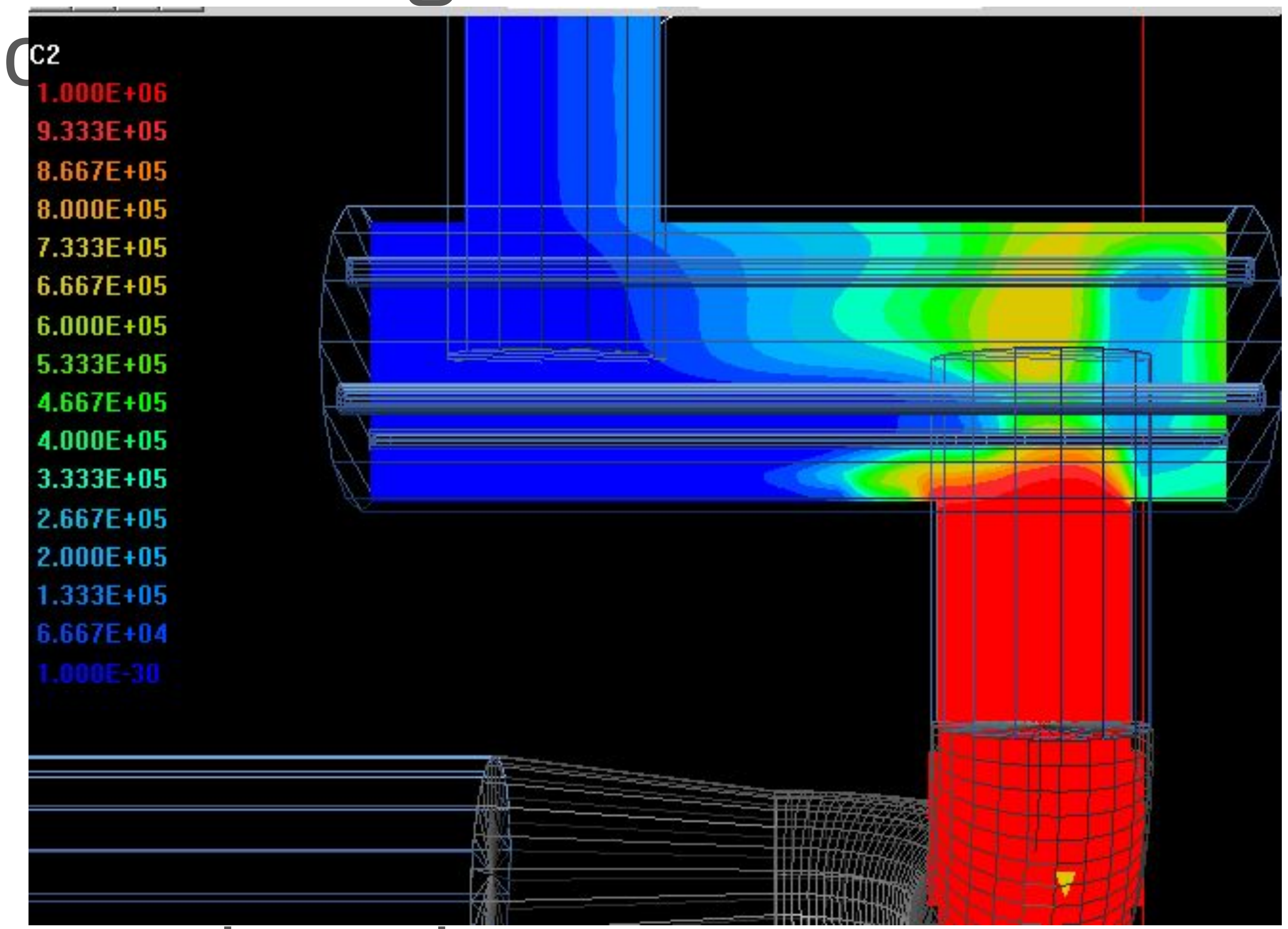

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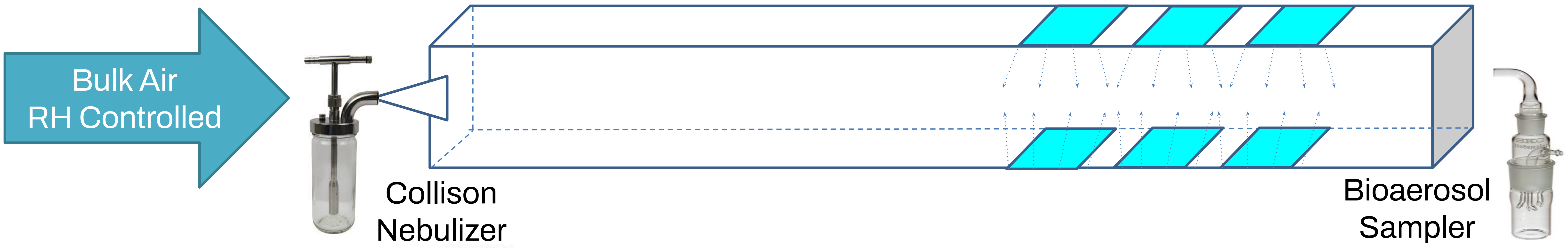
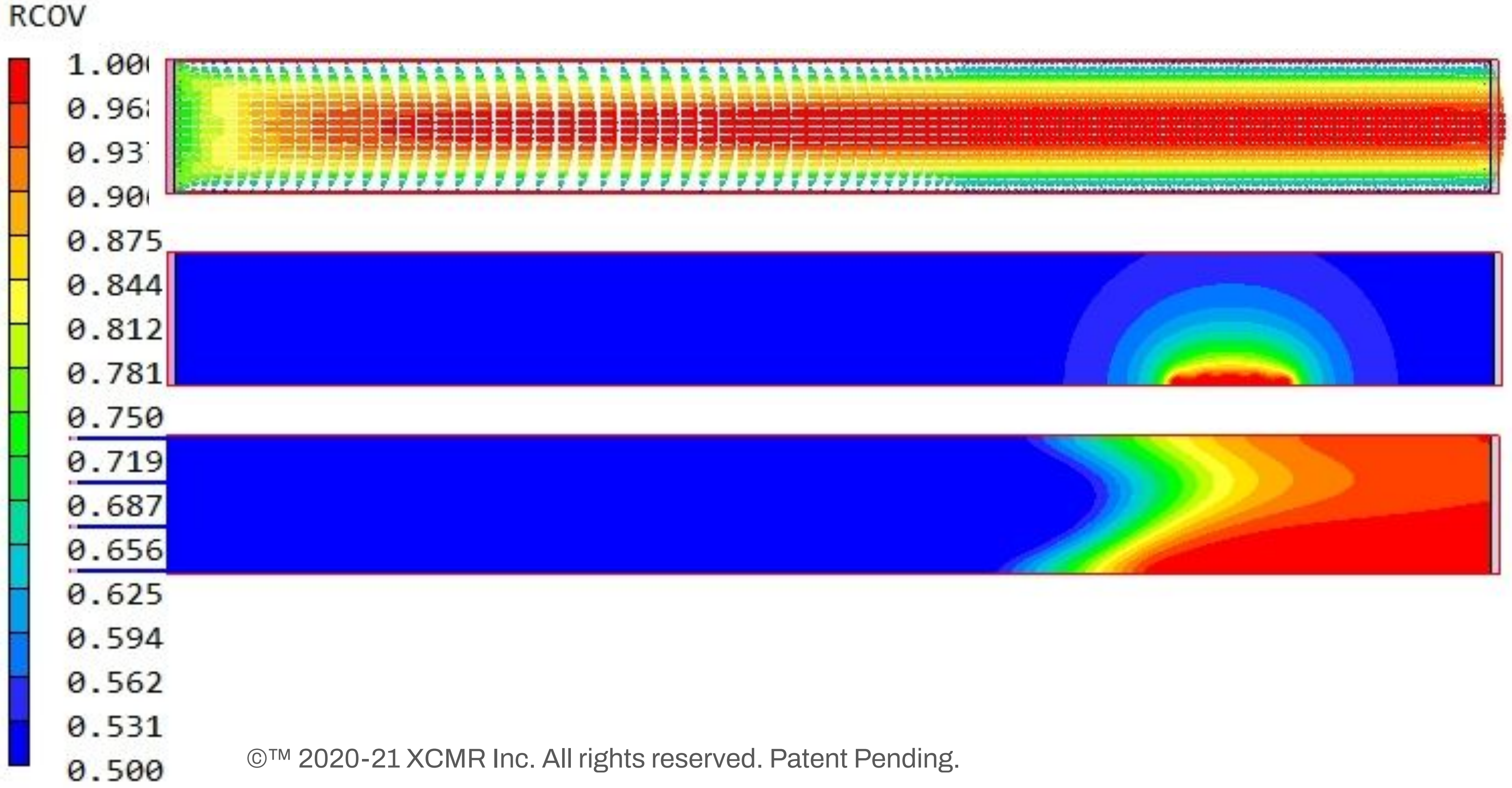
- A tool to better understand the process dynamics

Modeling and System Simulations to inform UV performance and Design optimization



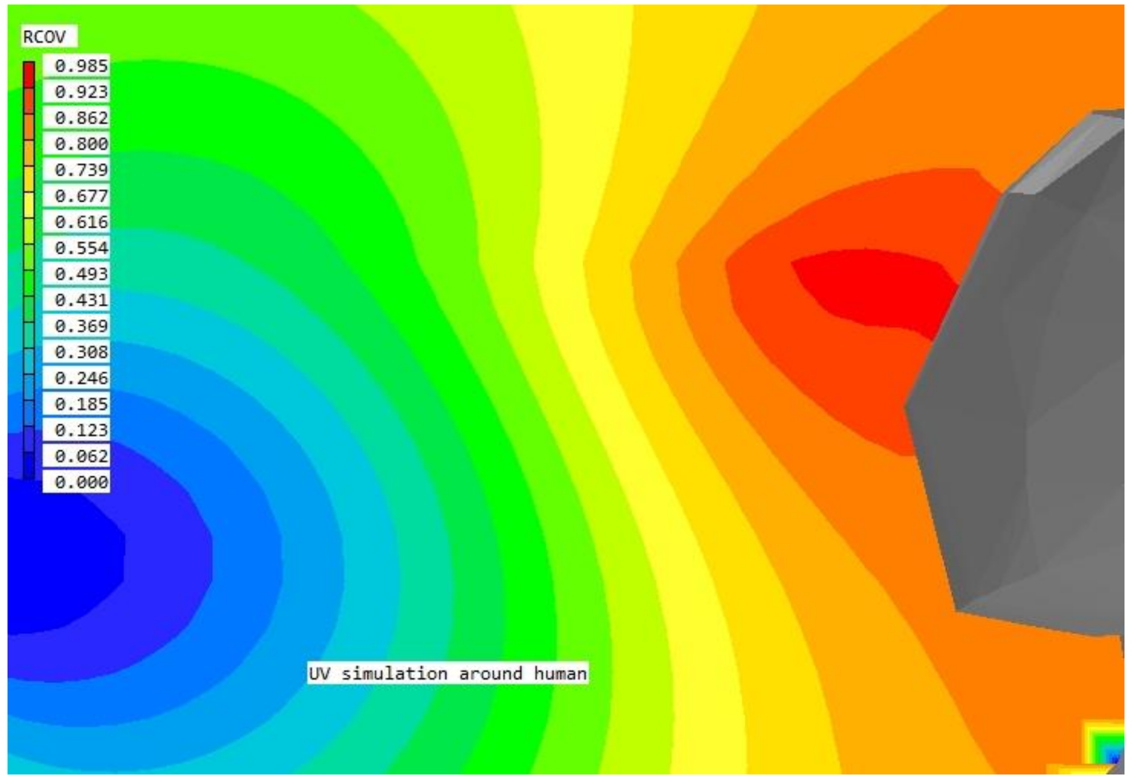


Modeling and System Simulations to inform UV performance and Design optimization

Velocity

Fluence Rate

Inactivation



- With these additional capabilities
  - Cost effective optimal solutions are created
  - For Targeted human health protection

Informing the Future of Decontamination

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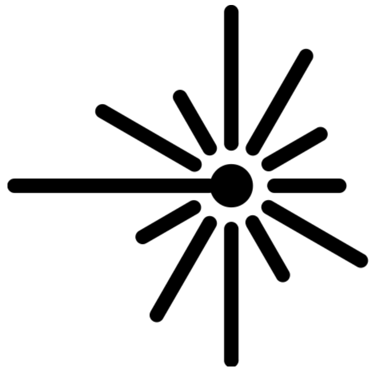
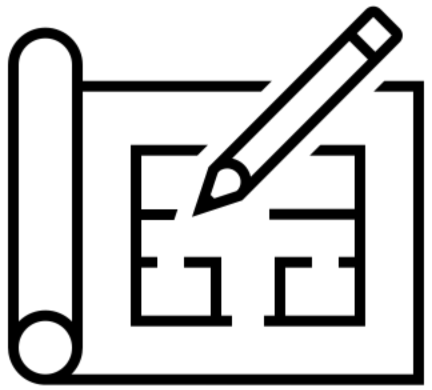
- FAR UVC SOURCES – PHOTONICS
  - Advent of new and emerging sources that more efficiently generate Far UVC
  - Optimize Far UVC sources for small, mobile, and personal uses (NIP) vs. large volume (public) spaces



- DECONTAMINATION – BIOLOGY
  - Use of benchtop (powerful, consistent spectra) lamps to determine inactivation constants for pathogens and surrogates
  - Airborne in respiratory fluids, and on dried surfaces

- ENGINEERING – INTEGRATION – MODELING
  - Determine optimal use of 222 nm emission for decontamination (i.e., geometry, modeling/simulation using computational fluid dynamics)
  - IoT M2M protocol between NIP devices and embedded public systems to provide a fully coordinated multi-layered approach to biodefense in both detection and hazard mitigation
  - *Applicable to PPE as well as large volume space decontamination*



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