Far UV-C Radiation for Personal Protection Against Airborne Pathogens

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Far UV-C

- Effective for inactivation of airborne pathogens
- Less potential to cause damage to human skin & eyes than longer wavelengths of UV-C radiation

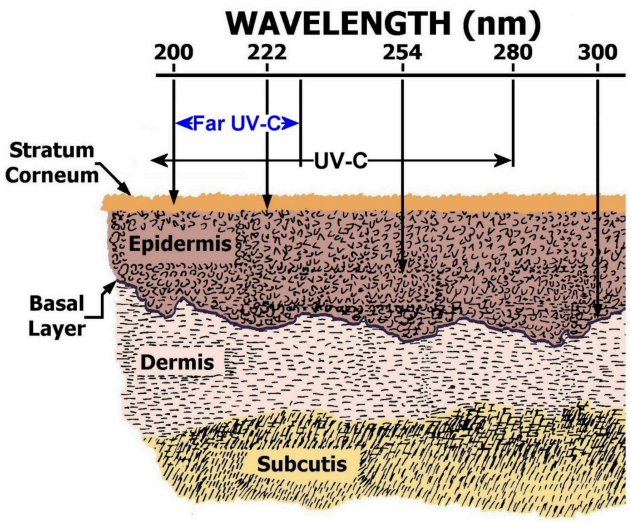
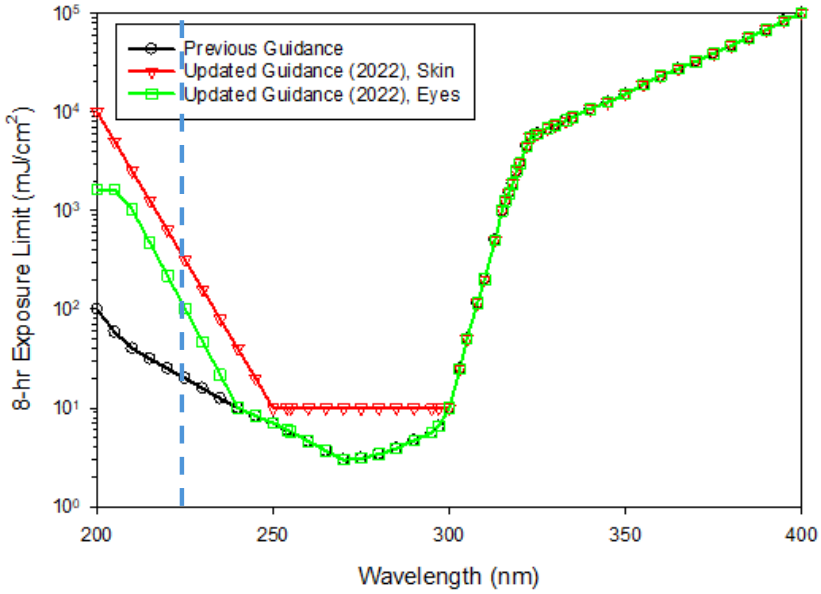


Image courtesy of David Sliney

Skin: 479 mJ/cm^2, eyes:161 mJ/cm^2

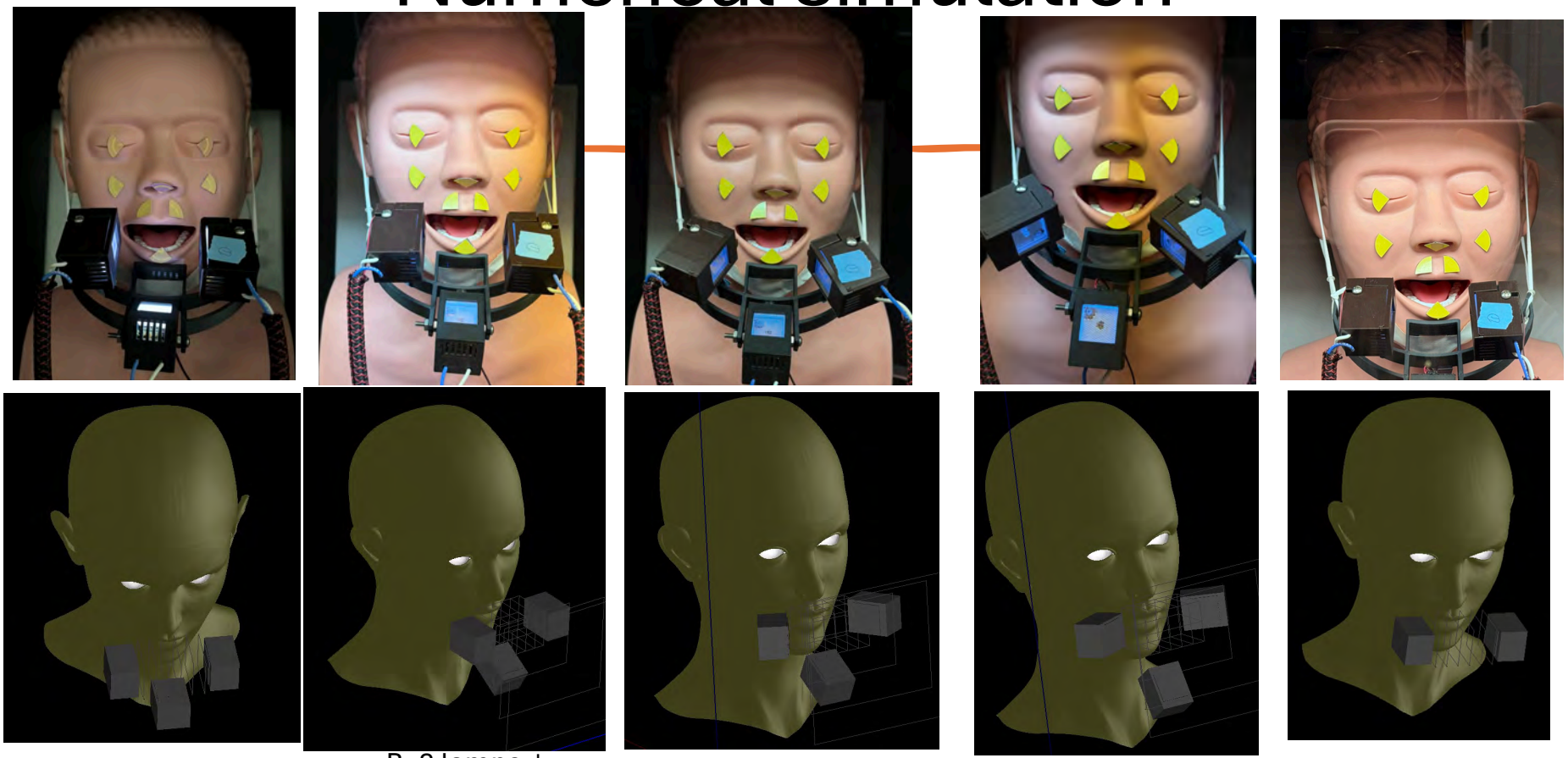


Previous and current TLVs (Blatchley III, et al., 2023)

Alterative to filtering mask – Far UV-C mask

- Far UV-C source: 222nm optically-filtered, flat-panel KrCl* plasma lamps
- Numerical simulations:
  - Fluence rate field modeling
  - Computational fluid dynamics
- Laboratory-based measurements:
  - Quantify human exposure: fluence rate field measurement using colorimetric dose cards
  - Quantify aerosolized viral inactivation with T1 phage as challenge agent

Numerical simulation



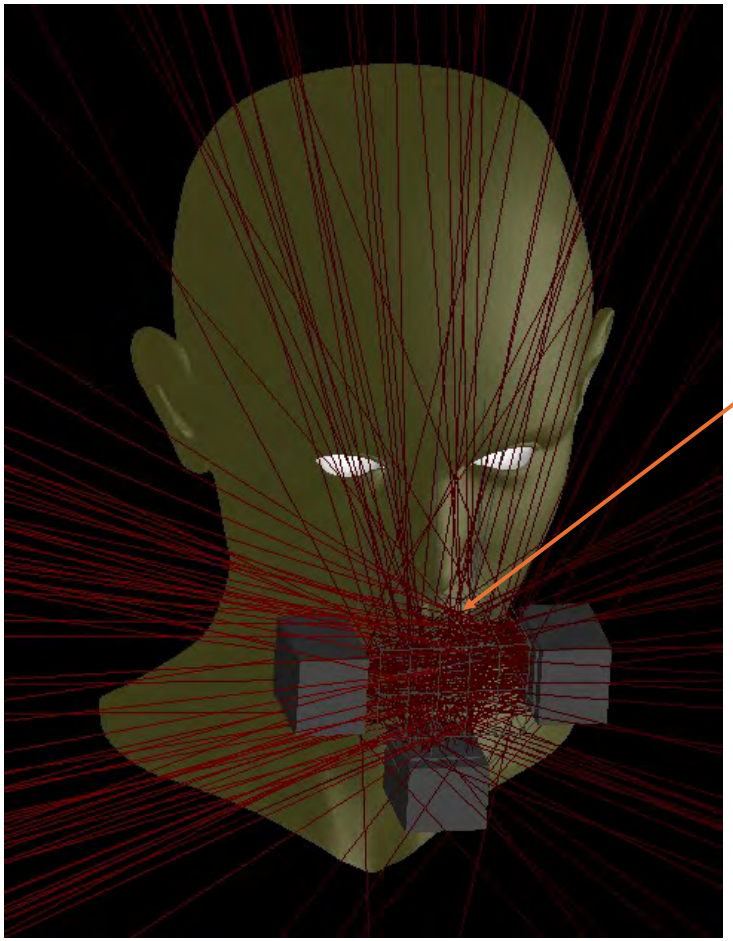
A: 3 lamps ⊥

B: 2 lamps ⊥,
1 @ 30º out

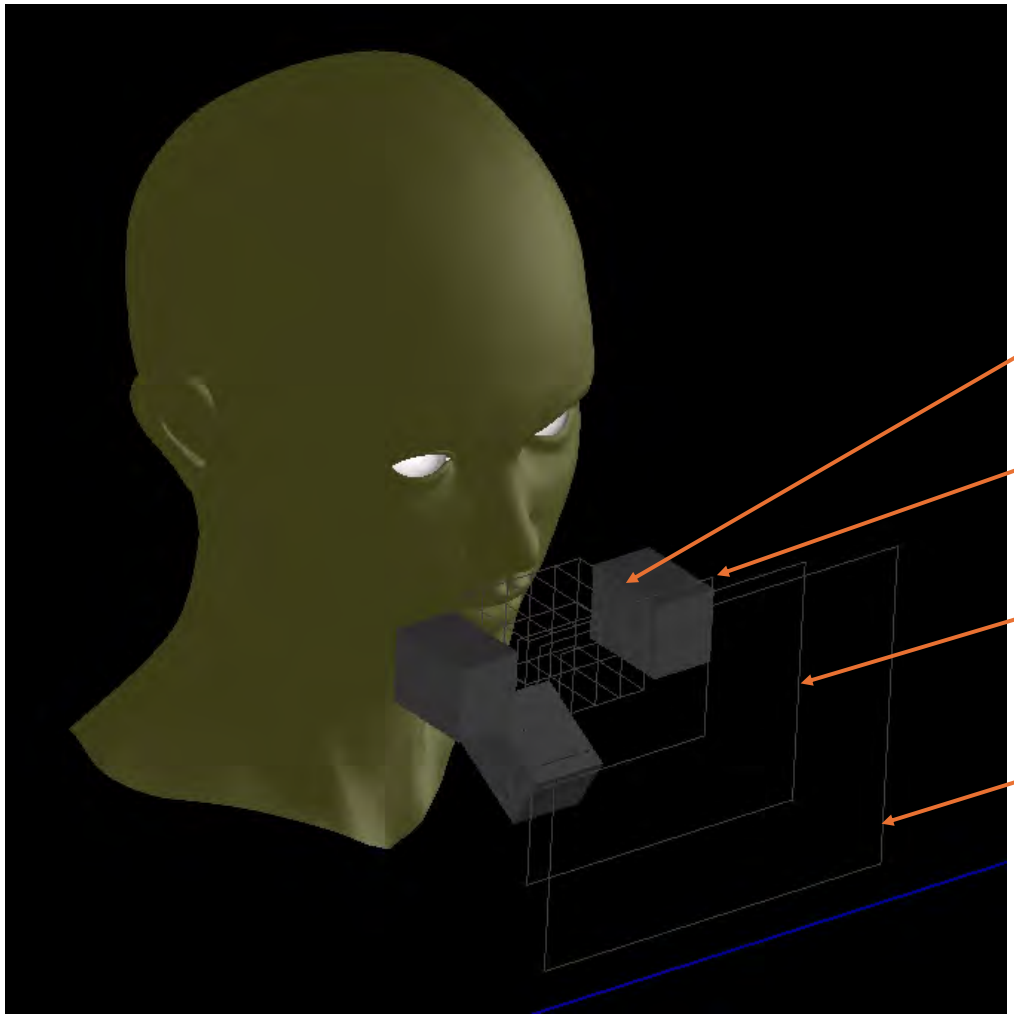
C: 3 @ 30º out

D: 3 @ 60º out

E: 2 lamps ⊥



Fluence rate = 0.516 mW/cm2



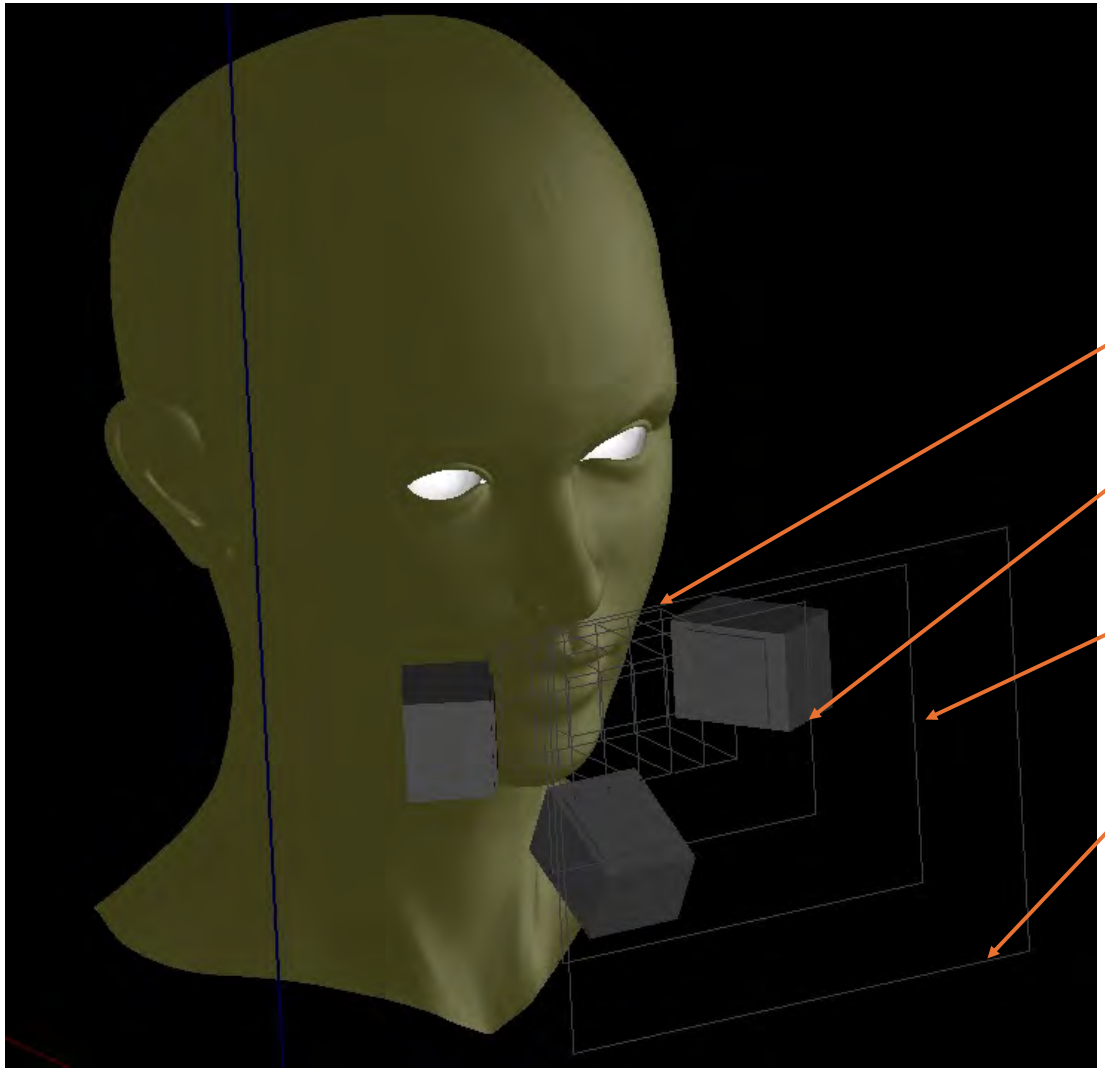
Total measured fluence rate = 0.54 mW/cm2

Fluence rate = 0.490 mW/cm2, 1-2 in from face

Fluence rate = 0.0333 mW/cm2, 3 in from face

Fluence rate = 0.00822 mW/cm2, 4 in from face

Fluence rate = 0.00353 mW/cm2, 5 in from face



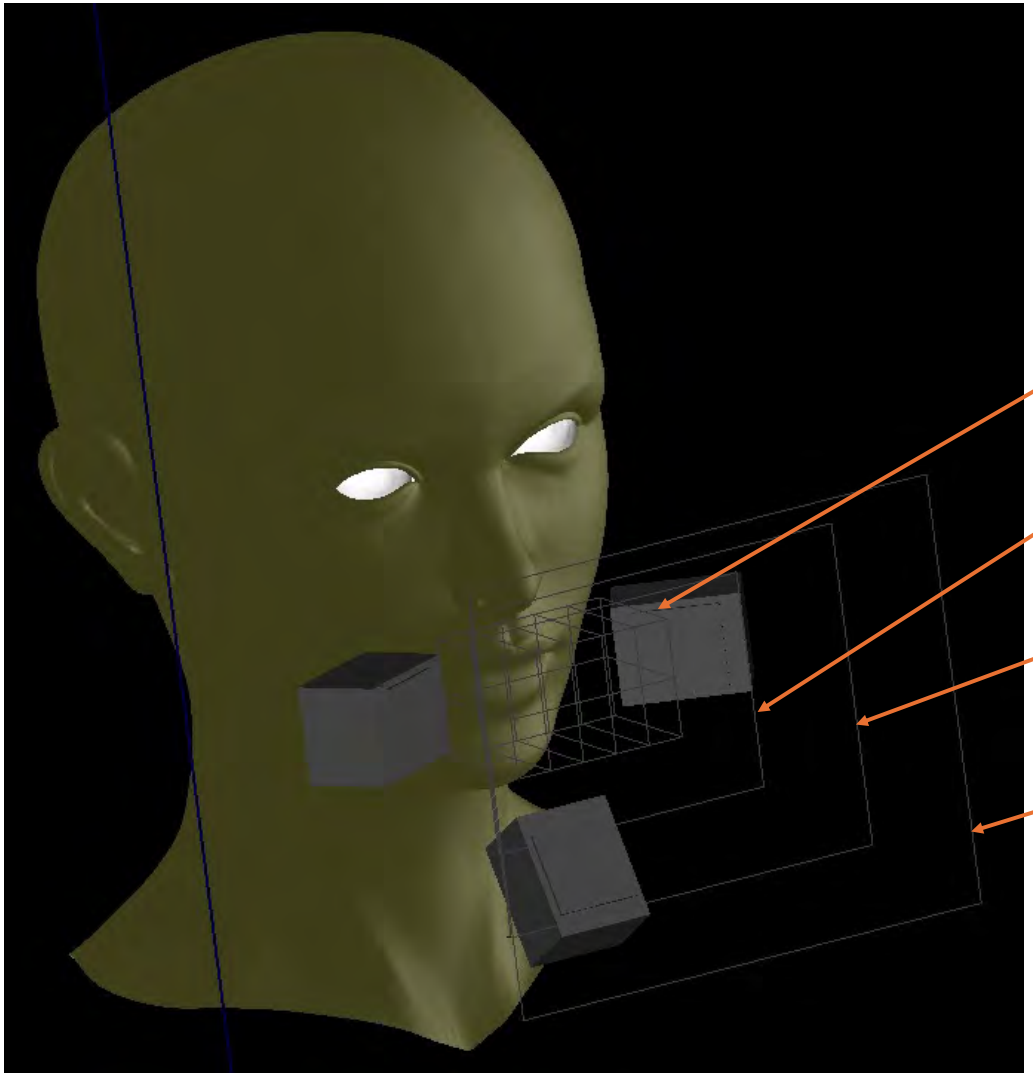
Total measured fluence rate = 0.41 mW/cm2

Fluence rate = 0.304 mW/cm2, 1-2 in from face

Fluence rate = 0.075 mW/cm2, 3 in from face

Fluence rate = 0.023 mW/cm2, 4 in from face

Fluence rate = 0.0094 mW/cm2, 5 in from face



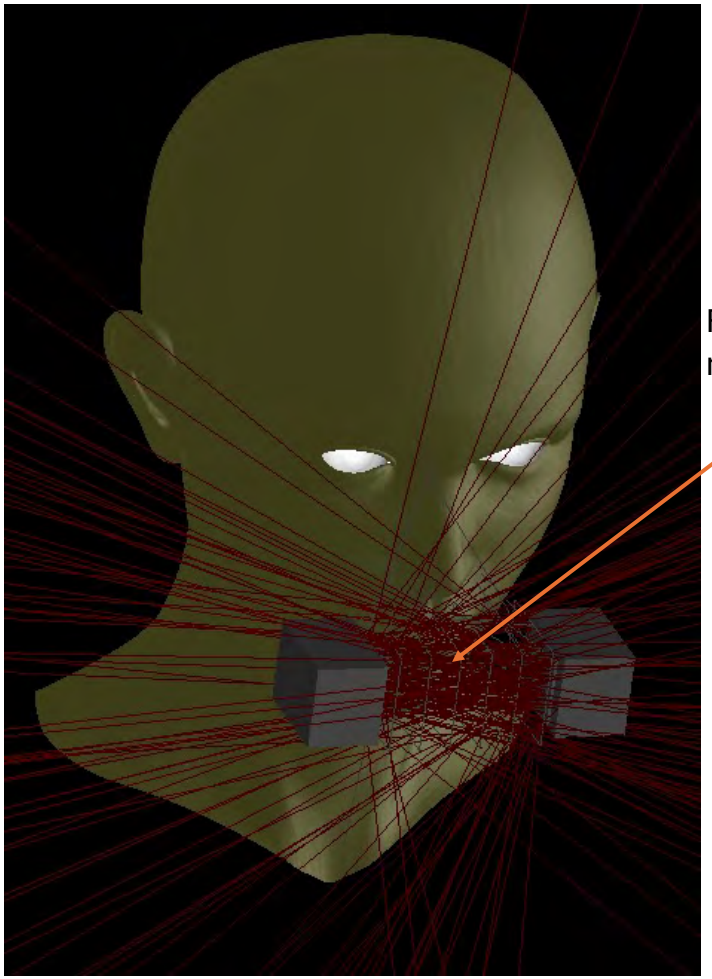
Total measured fluence rate = 0.3080 mW/cm2

Fluence rate = 0.10 mW/cm2, 1-2 in from face

Fluence rate = 0.124 mW/cm2, 3 in from face

Fluence rate = 0.057 mW/cm2, 4 in from face

Fluence rate = 0.029 mW/cm2, 5 in from face

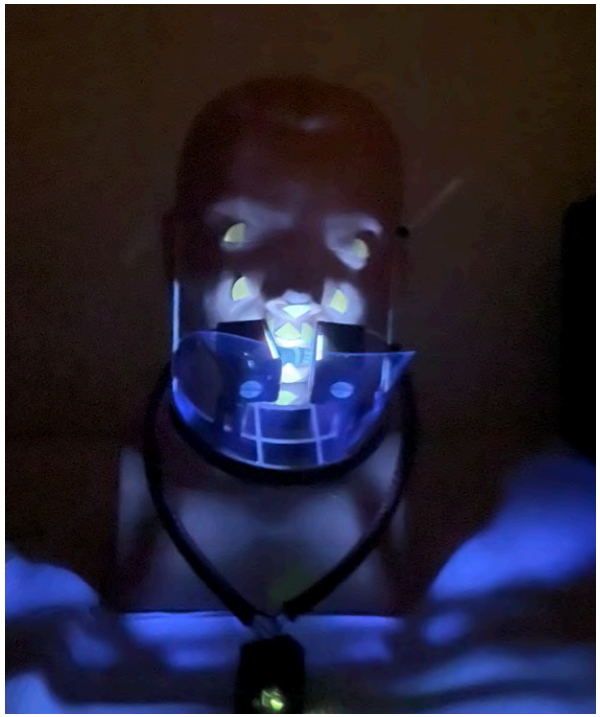


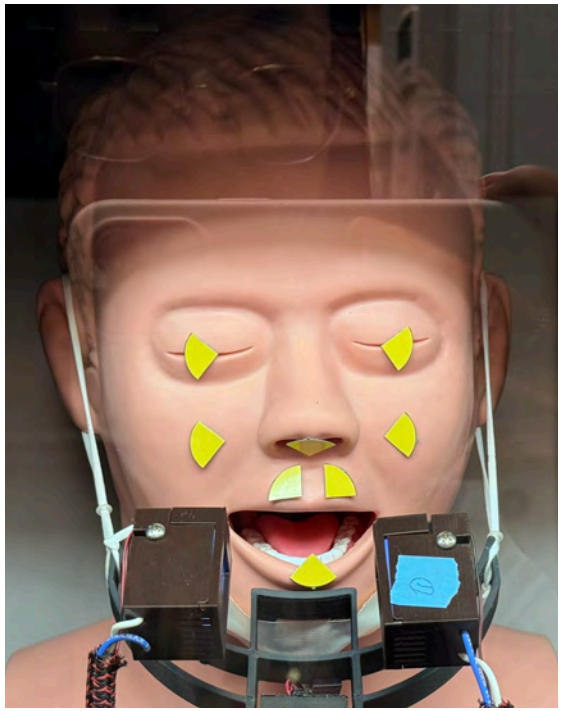
Fluence rate = 0.315 mW/cm2

Fluence rate field measurement using colorimetric dosimetry cards

Color development for colorimetric dosimetry cards for a range of well-defined UV222 doses. Doses each card was exposed to are defined by the hand-written labels on each card.

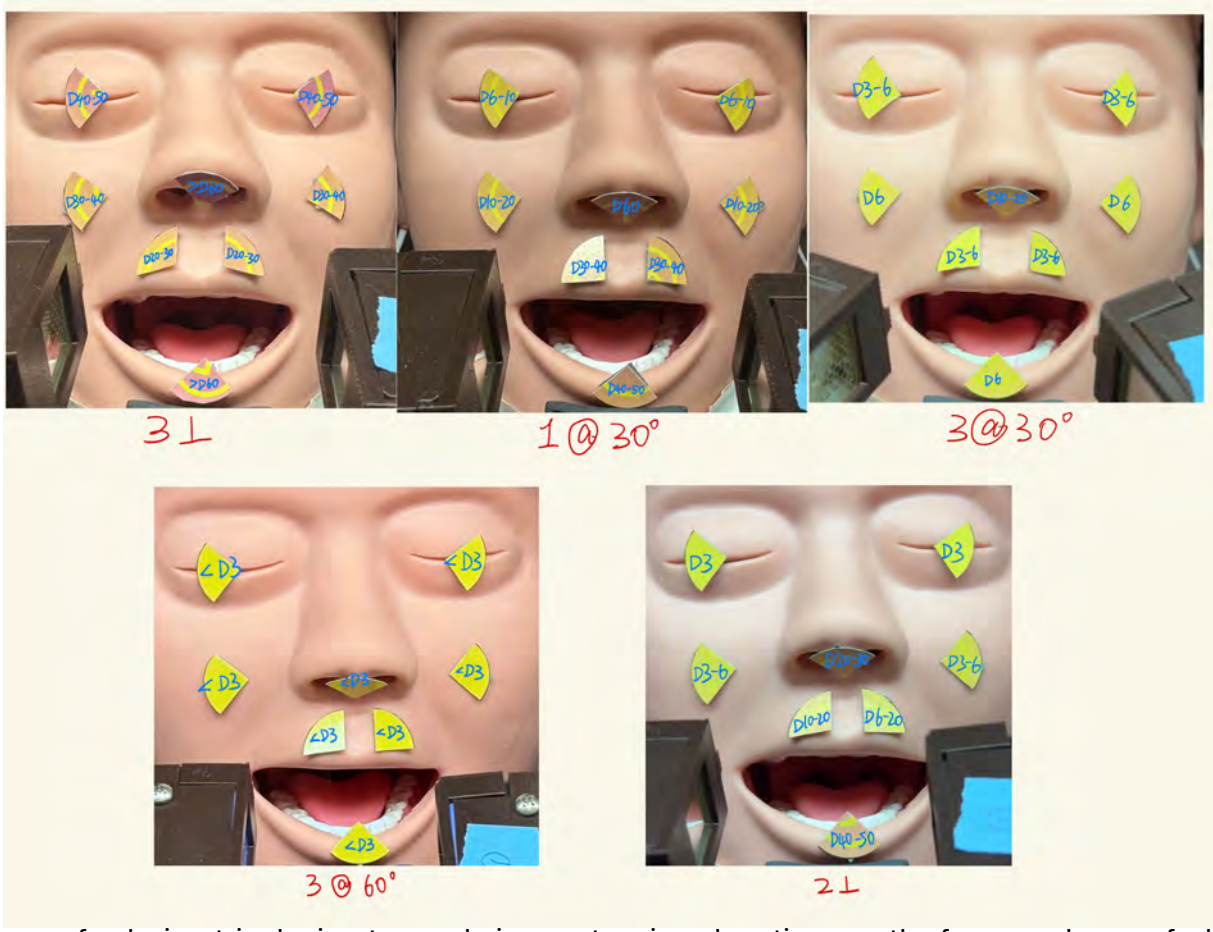
Fluence rate field measurement using colorimetric dosimetry cards





Photographic images of pieces of colorimetric dosimetry card affixed to the face and eyes of a human manikin with the Eden Park mask.

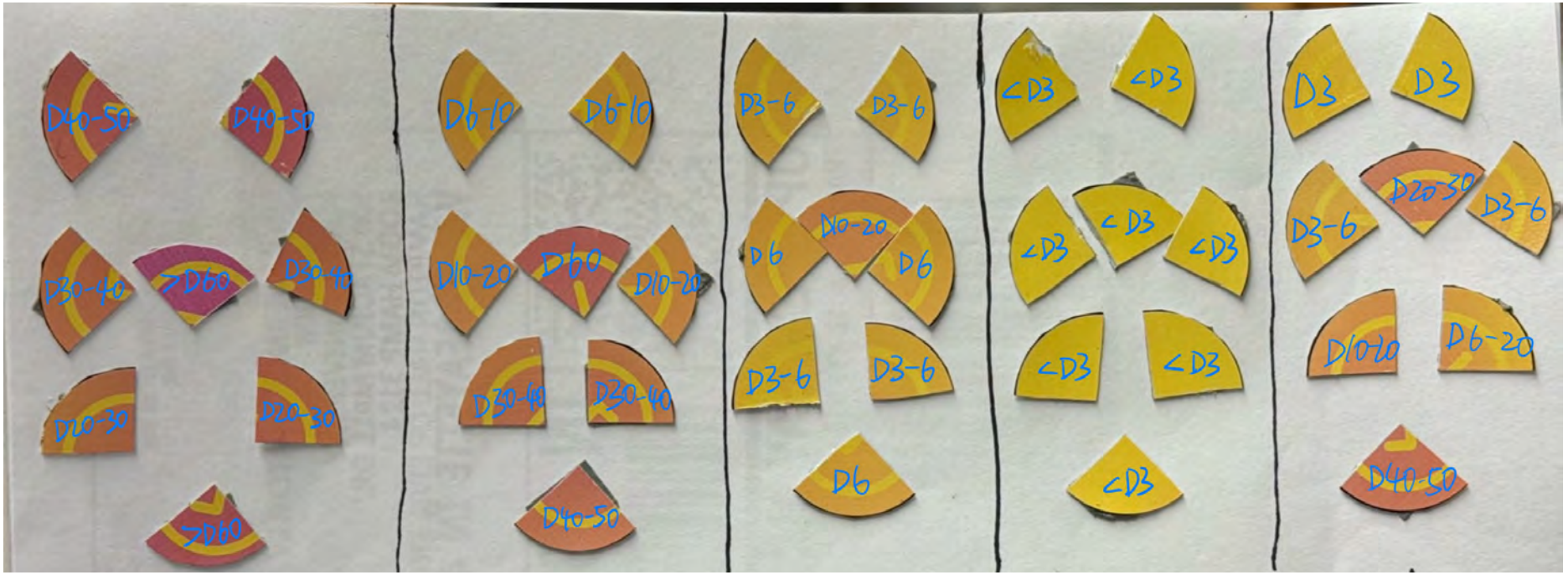
Fluence rate field measurement using colorimetric dosimetry cards



Photographic images of colorimetric dosimetry card pieces at various locations on the faces and eyes of a human manikin after 1 hour irradiation

Fluence rate field measurement using colorimetric dosimetry cards

TLVs - Skin: 479 mJ/cm^2, eyes:161 mJ/cm^2 for 8 hours exposure



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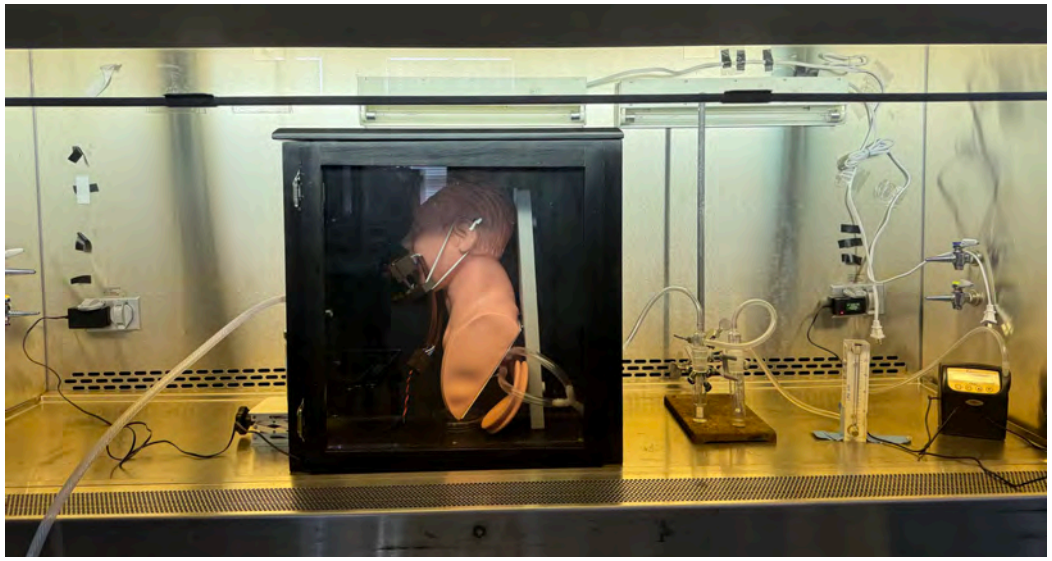
C: 3 @ 30° out

D: 3 @ 60° out

E: 2 lamps ⊥

Photographic images of colorimetric dosimetry card pieces at various locations on the faces and eyes of a human manikin after 1 hour irradiation

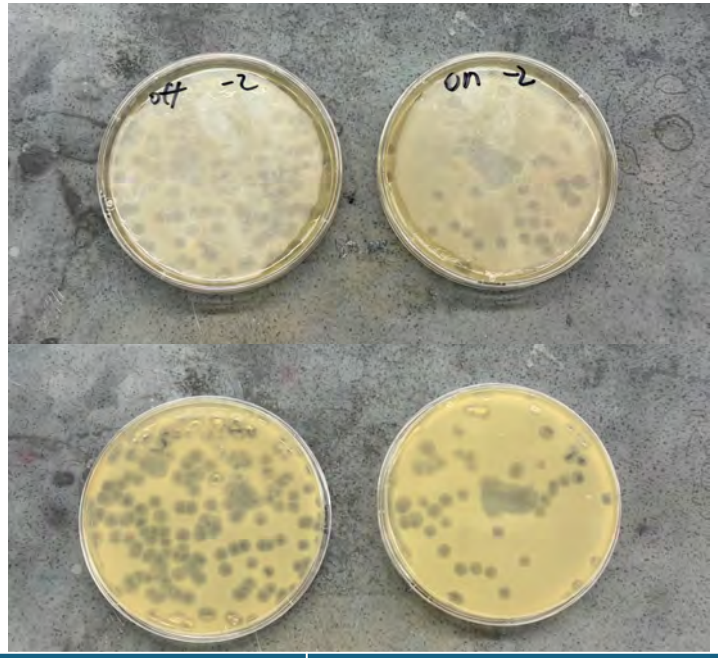
Far UV-C mask aerosolized viral inactivation test set up



Flow rate: 2.5 L/min
Phage in nebulizer: T1
Phage quantification method: EPA 1602

Condition
3 lamps perpendicular
Neb off + lamps off
2 lamps perpendicular, 1 lamps at 30 degrees outwards
Neb off + lamps off
3 lamps at 30 degrees outwards
Neb off + lamps off
3 lamps at 60 degrees outwards
Neb on + lamps off

Results

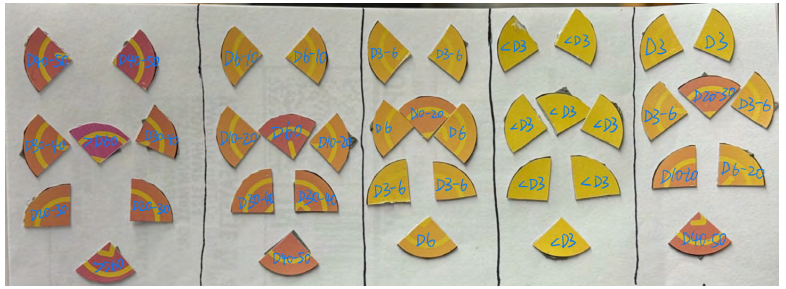


Condition	Phage concentration in sampler (PFU/mL)
E: 2 lamps ⊥	$60 \times 10^2/0.5 = 1.2 \times 10^4$
Neb on + lamps off	$178 \times 10^2/0.5 = 3.56 \times 10^4$

One plasma lamp irradiance measurement before and after 10 min sampling:

- Before: 0.385 mW/cm^2
- After: 0.374 mW/cm^2

Results



Condition	0	-1	-2	-3
A: 3 lamps ⊥	TN	47	5	0
Neb off + lamps off	11	1	0	0
B: : 2 lamps ⊥, 1 @ 30º out	TN	47	5	2
Neb off + lamps off	30	4	0	0
C: : 3 @ 30º out	TN	56	1	0
Neb off + lamps off	37	6	2	0
D: 3 @ 60º out	TN	100	14	3
Neb on + lamps off	TN	93	8	0

N/N_0

0.52

0.52

0.60

~1

Summary and Conclusions

- Dosage received by manikin A>B>C>D, E between B and C. Configuration C and D could meet the TLVs.
- Configuration A, B, C display similar inactivation, while configuration C gas lowest human exposure and can meet TLVs
- Configuration D 3 @ 60º out shows close to non inactivation. Dark zones were evident behind lamps, which may have allowed air flow into manikin mouth without being irradiated.
- System performance is constrained by low source output power

Acknowledgements

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