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High Performance UVC LEDs

How UVC LEDs Can Help Combat the Spread of Healthcare-Associated Infections (HAIs)

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Crystal IS™

Healthcare Acquired Infection (HAI)

CDC
Centers for Disease Control and Prevention

	2012		2013		2014		Average HAI/Facility			
	Facilities Reporting	Observed HAI	Facilities Reporting	Observed HAI	Facilities Reporting	Observed HAI	2012	2013	2014	Trend
CLABSI	3,516	17,710	3,578	17,799	3,655	17,758	**5.04**	**4.97**	**4.86**	↘
CAUTI	3,597	32,504	3,640	34,627	3,791	35,760	**9.04**	**9.51**	**9.43**	→
Hospital-onset MRSA bacteremia	1,175	2,618	3,827	9,471	3,949	9,230	**2.23**	**2.47**	**2.34**	→
Hospital-onset C. difficile	1,681	40,491	3,924	99,550	3,994	101,074	**24.09**	**25.37**	**25.31**	↗
SSI, Combined SCIP Procedures	3,554	13,770	3,581	14,951	3,618	15,927	**3.87**	**4.18**	**4.40**	↗
		107,093		176,398		179,749				

"Although significant progress has made in preventing some infection types, **there is much more work to be done**. On any given day, about one in 25 hospital patients has at least one healthcare-associated infection.

Source: CDC "2012 National and State HAI Progress Report", "2013 National and State HAI Progress Report", "2014 National and State HAI Progress Report"

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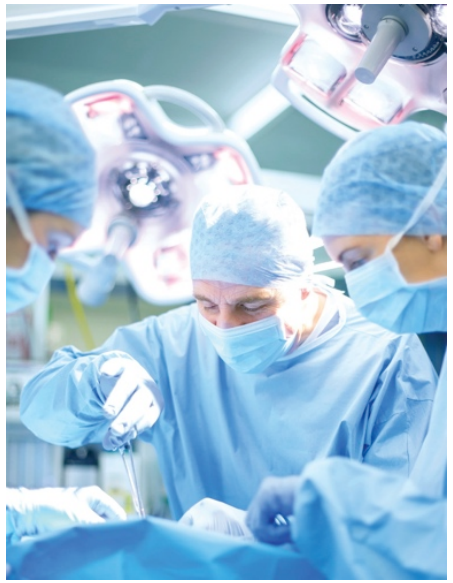
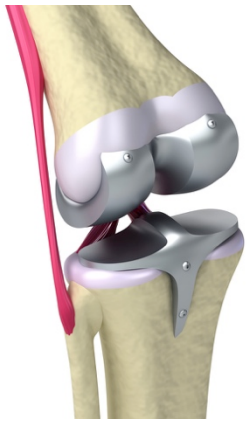
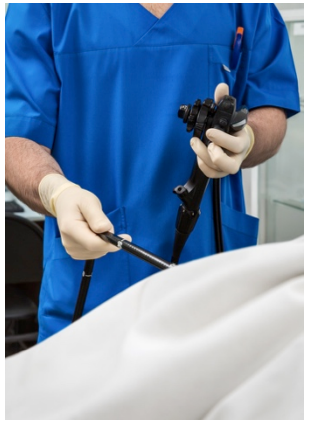
Helping to Address: SSI

Example: Disinfecting complex tool shapes in the ER

- Address Complex shapes
  - Implants
  - Reusable Devices







Consider: Custom devices combining LEDS in close proximity to complex surfaces

Helping to Address: CDI
Example: General Disinfection

- Portable Nurse Stations
- Portable Electronic Devices
- Class 1-2 Medical Devices
- Stethoscopes/Otoscopes
- Pagers/ Cell phones

Consider: Embedded in rolling carts to disinfect high contact surfaces on-the-go

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Helping to Address: Respiratory Associated Illness
Example: Integration with Ventilator






Consider: Integration on rolling ventilator or embedded in disposable mask

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Helping to Address: CLABSI
Example: Automating "Scrub the Hub "Wiping procedures

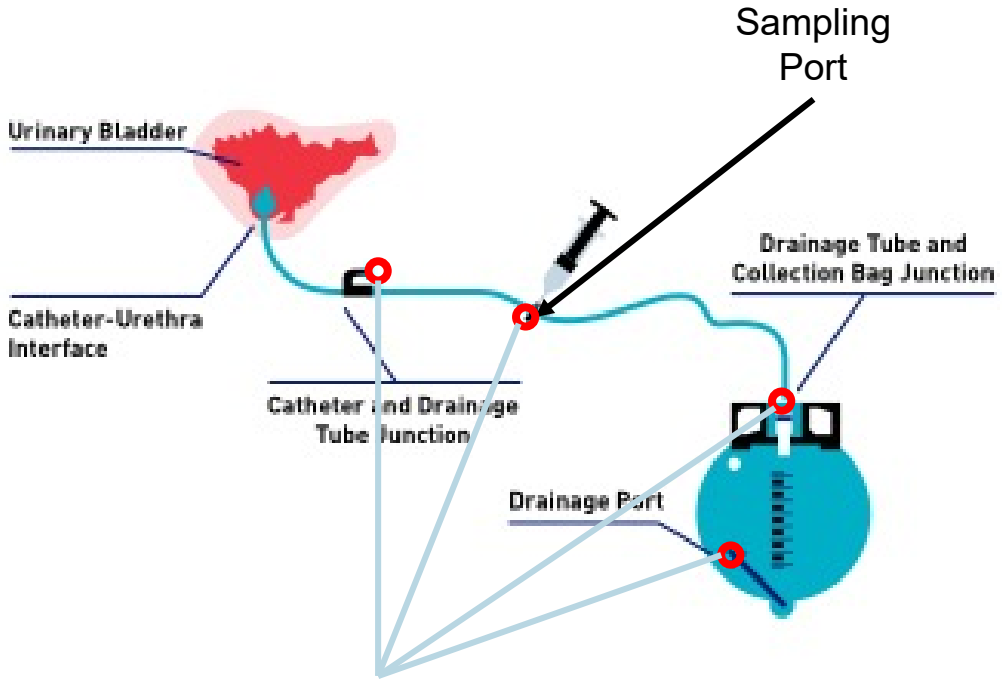
- Currently a manual process
- No verifiable means of compliance
- It takes TIME. 60 seconds can seem like forever.
- Incomplete procedure can still leave behind harmful bacteria

Consider: Portable hand held devices or integration with Infusion Machines

Helping to Address: CAUTI
Example: Daily Catheter Maintenance

Little reduction in HAI Incidence

- A Manual Process
- No verifiable means of compliance
- Incomplete procedure can still leave behind harmful bacteria
- Several high contact surfaces



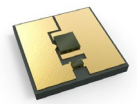
Typical Sites of Pathogen Growth

Consider: Hand held device or rolling disinfection cart

LEDs are Suited to Handheld & Portable Applications

Very Compact & Durable

3.5 mm x 3.5 mm

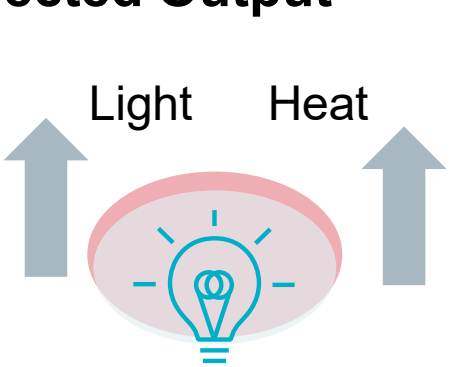


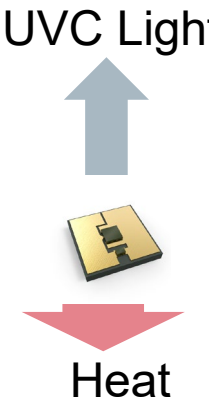
5 could fit across the face of a penny

Low Voltage / Energy

6.7 W-hr Battery
- >1.5 hr of Operation

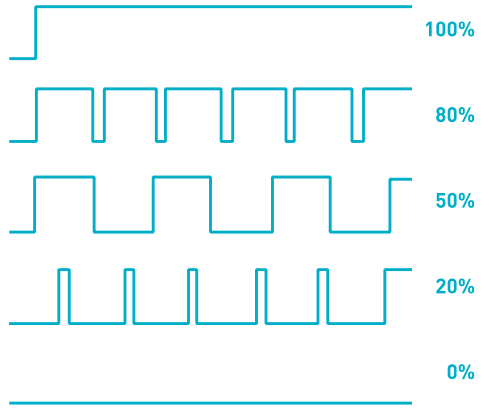
Directed Output





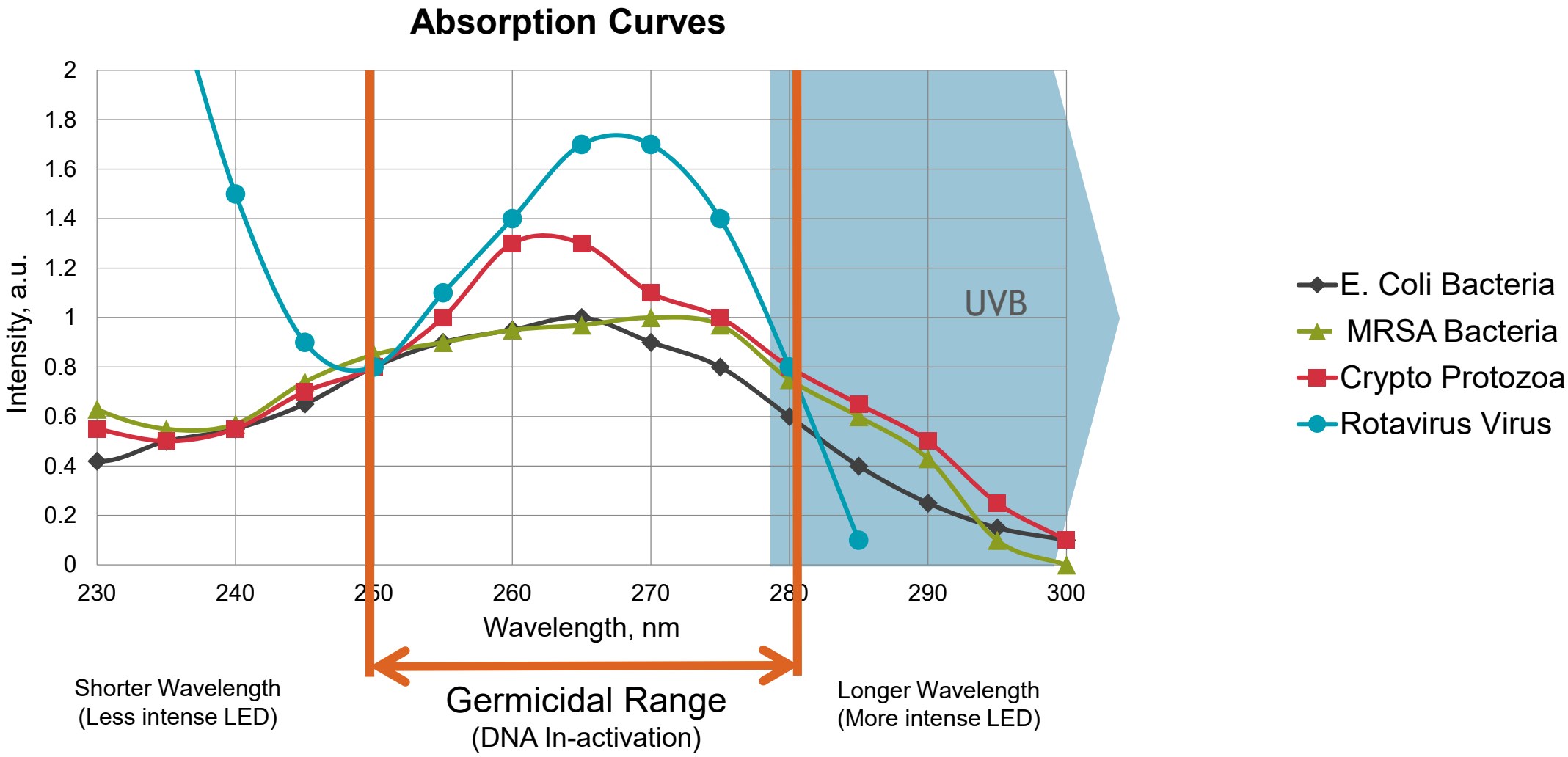
Instant On/Off

- Flexible Duty Cycle
- High Cycle capability



Broad design flexibility & performance to provide **quantifiable disinfection**

Disinfection: Spectral Sensitivity



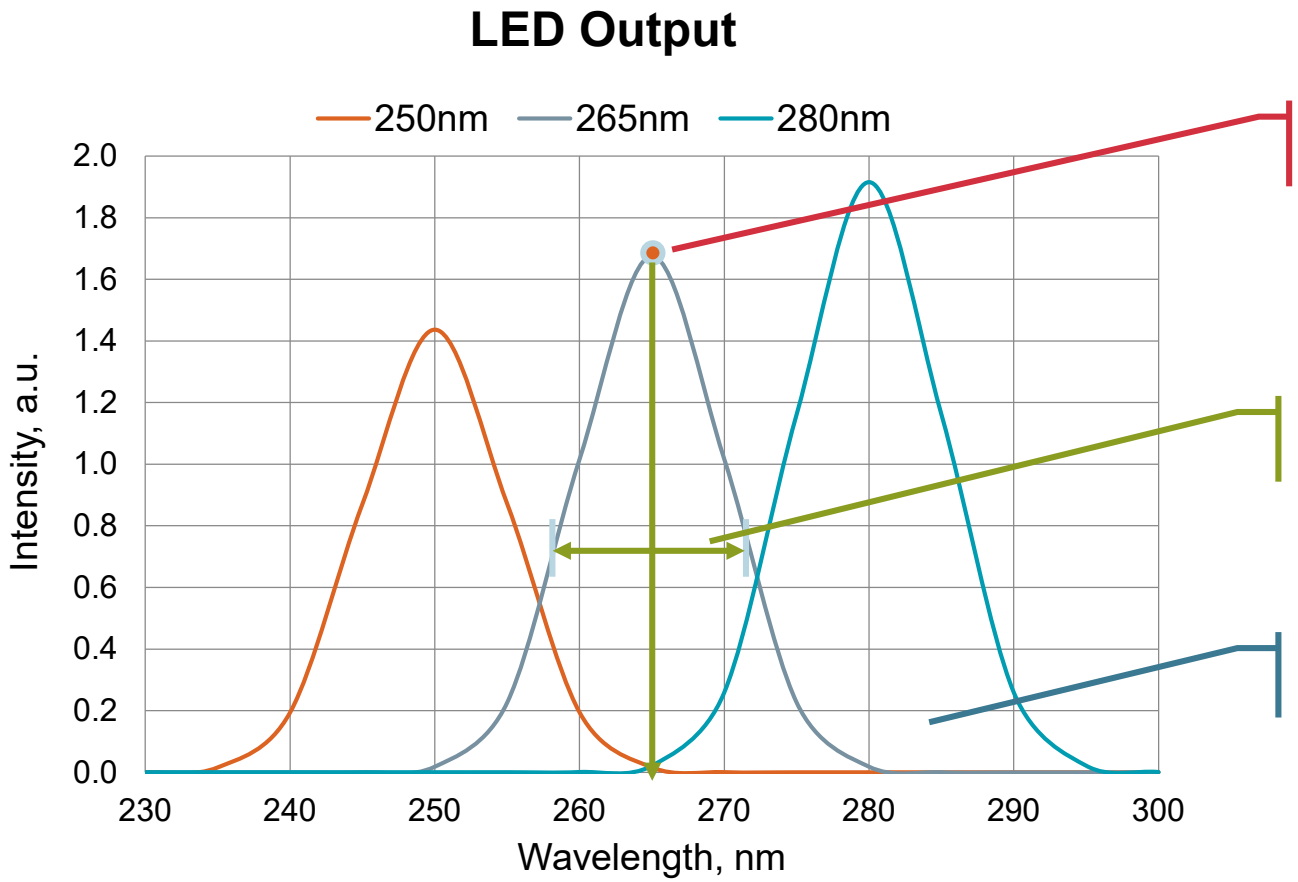
List of Microbes

Wavelength	Adenovirus	Bacillus Pumilis Spores	EMC	Bacillus Subtilis Spore	Cryptosporidium parvum	E. Coli	MS2 Coliphage	FD	FX-174	Poloma	Qbeta coliphage	Salmonella typhimurium	Staphylococcus Aureus	T1 Coliphage	T2 Coliphage	T7 Coliphage	VSW	Vaccinia
nm	GF	GF	GF	GF	GF	GF	GF	GF	GF	GF	GF	GF	GF	GF	GF	GF	GF	GF
250	0.6	1.02	0.952	0.852	0.833	0.811	0.836	0.89	0.888	0.966	0.82	0.733	0.963	0.677	0.987	0.824	0.832	0.831
254	1	1	1.074	1	1.015	1.015	1.013	1	1	1	1.015	1	1.0023	1.022	1	1.015	1	1.015
260	1.53	1.389	1.192	1.191	1.26	1.259	1.22	1.13	1.17	1.233	1.24	1.129	1.042	1.261	1.119	1.31	1.119	1.21
265	1.699	1.65	1.222	1.409	1.259	1.345	1.216	1.19	1.24	1.42	1.236	1.082	1.05	1.203	1.236	1.488	1.07	1.22
270	1.641	1.3	1.099	1.571	1.14	1.27	1.1	1.187	1.188	1.417	1.1	1.03	1.017	1.023	1.259	1.49	0.905	0.998
275	1.437	1.097	0.9	1.314	1.018	1.038	0.952	1.09	1.09	1.19	0.914	0.9	0.935	0.946	1.168	1.25	0.72	0.71
280	1.17	0.953	0.735	0.899	0.88	0.709	0.78	0.884	0.98	0.81	0.72	0.722	0.811	0.951	0.978	0.92	0.59	0.531
285	0.905	0.753	0.587	0.55	0.698	0.355	0.579	0.616	0.697	0.541	0.544	0.531	0.65	0.602	0.71	0.661	0.445	0.421
290	0.649	0.492	0.41	0.295	0.49	0.099	0.36	0.35	0.372	0.353	0.38	0.353	0.442	0.228	0.42	0.46	0.274	0.287

Source: IUVA News, Vol 19, No. 2

UVC LED Characteristics

Polychromatic: Specified Based On Shape



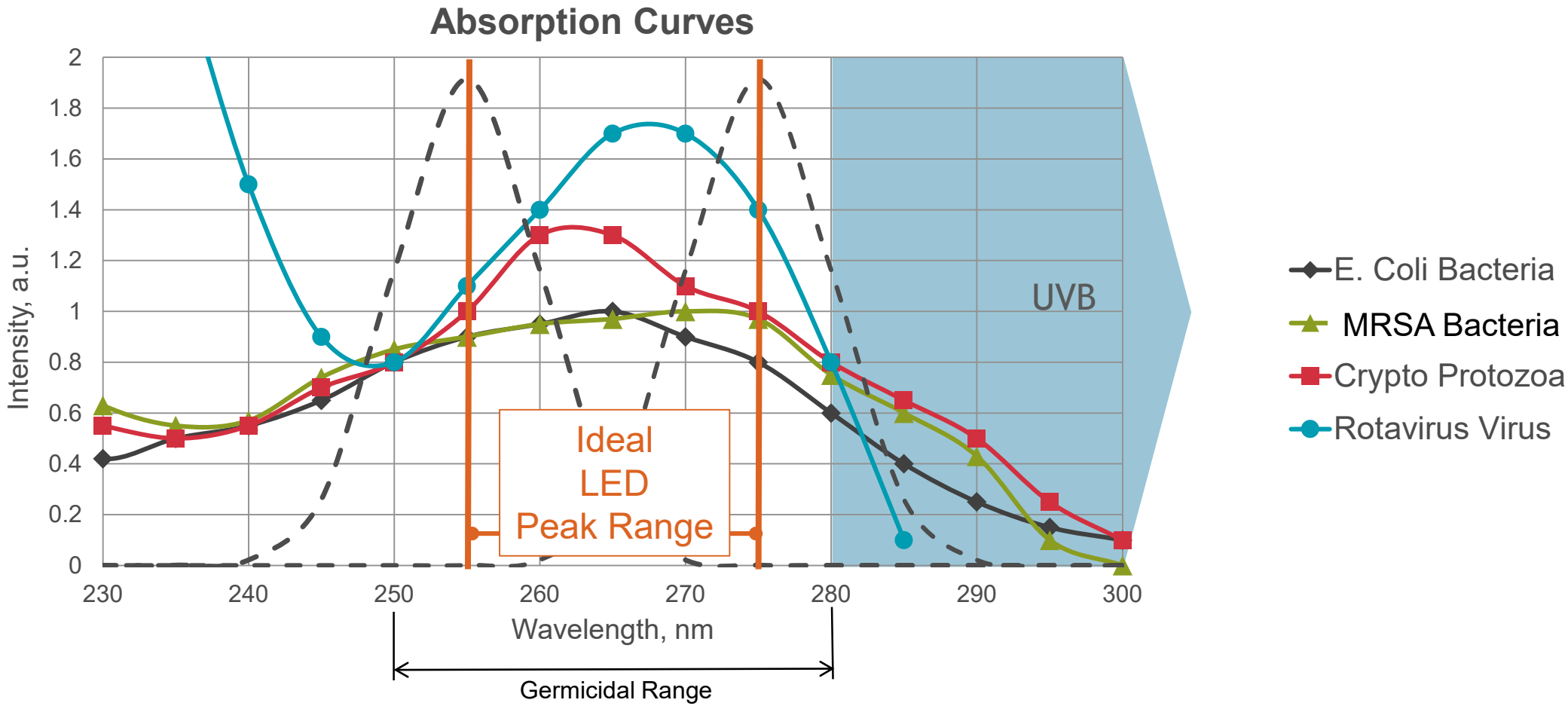
Peak Irradiance Wavelength
(265 nm Shown)

Width at Half Maximum
(FWHM, All typically 12-15nm)

Area under the curve
(Radiant Flux / Light Output)

LEDs Typically Differentiated on Peak Wavelength & Light Output

Combining Spectral Sensitivity & LED Characteristics

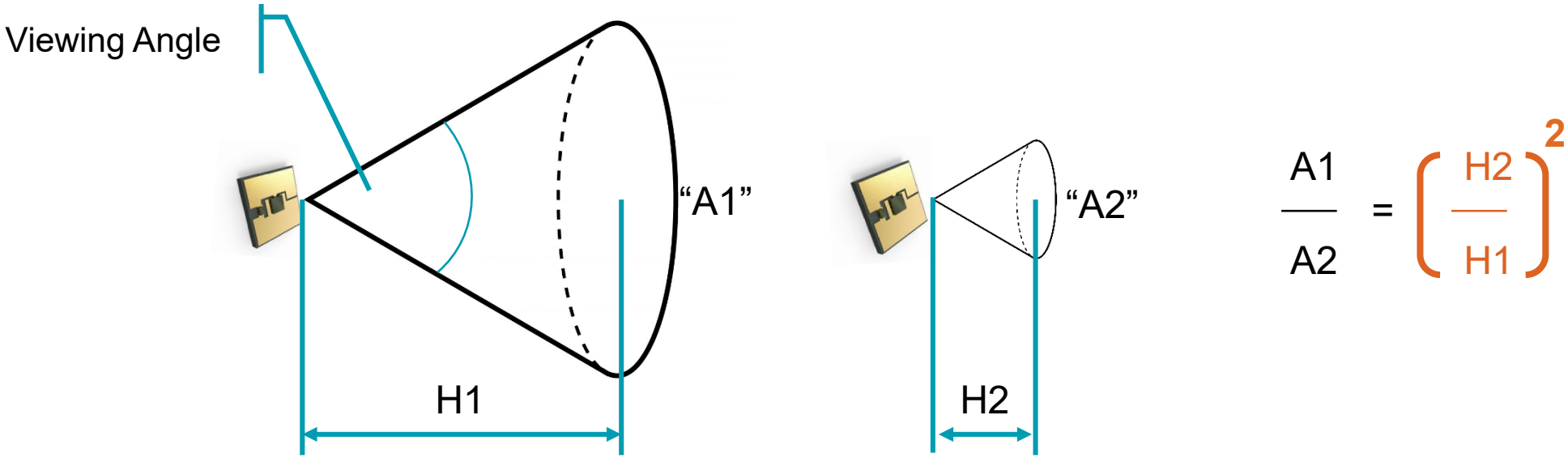


Broad absorption range but effective & consistent disinfection with Peaks 255 – 275nm

Dosage

$$\text{UV Dose } (mJ/cm^2) = \left(\frac{\text{Radiance } (mW)}{\text{Target Area } (cm^2)} \right) \times \text{Exposure Time } (secs)$$

Intensity



$$\frac{A1}{A2} = \left(\frac{H2}{H1} \right)^2$$

Disinfection Level = *f* (Radiance, Time, Distance)

Power and Lifetime

Lifetime and Power are two design variables, not absolute values

- **How to increase Power?**
  - Increase driving current
  - Increase number of LEDs (same current)
  - Optimize environment (reflective materials)
- **How to extend Lifetime?**
  - Reduce driving current
  - Pulse operation
  - Increase number of LEDs (lower current)

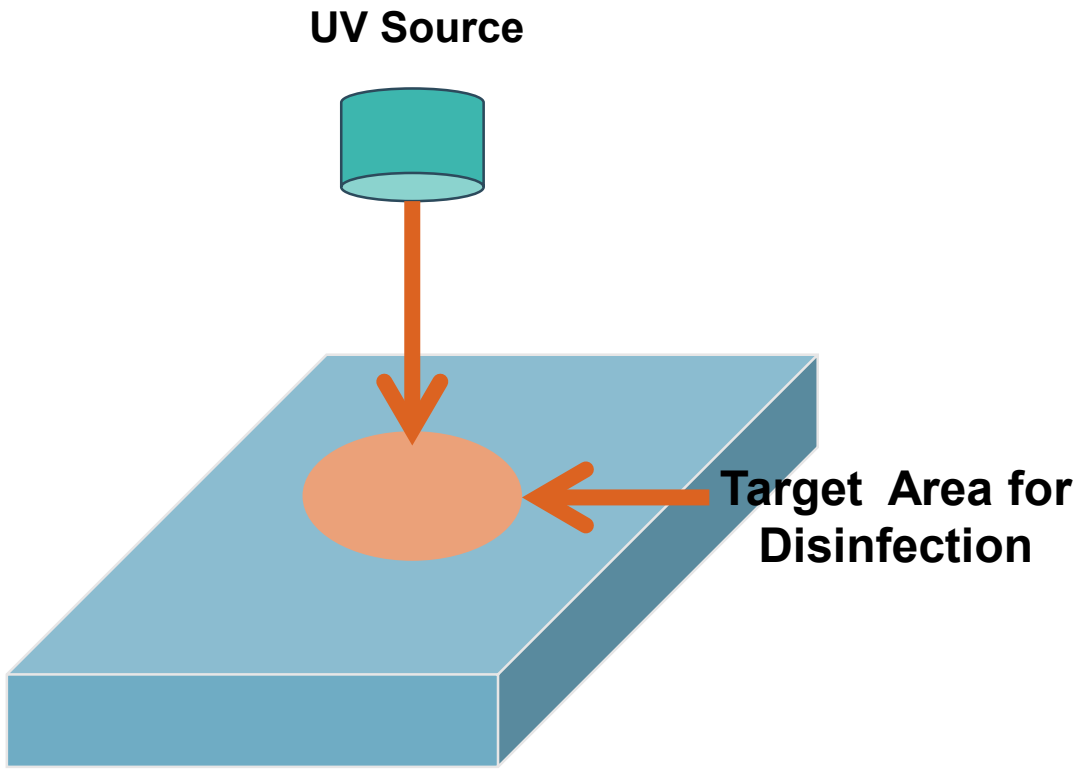
Design Considerations

Surface Disinfection

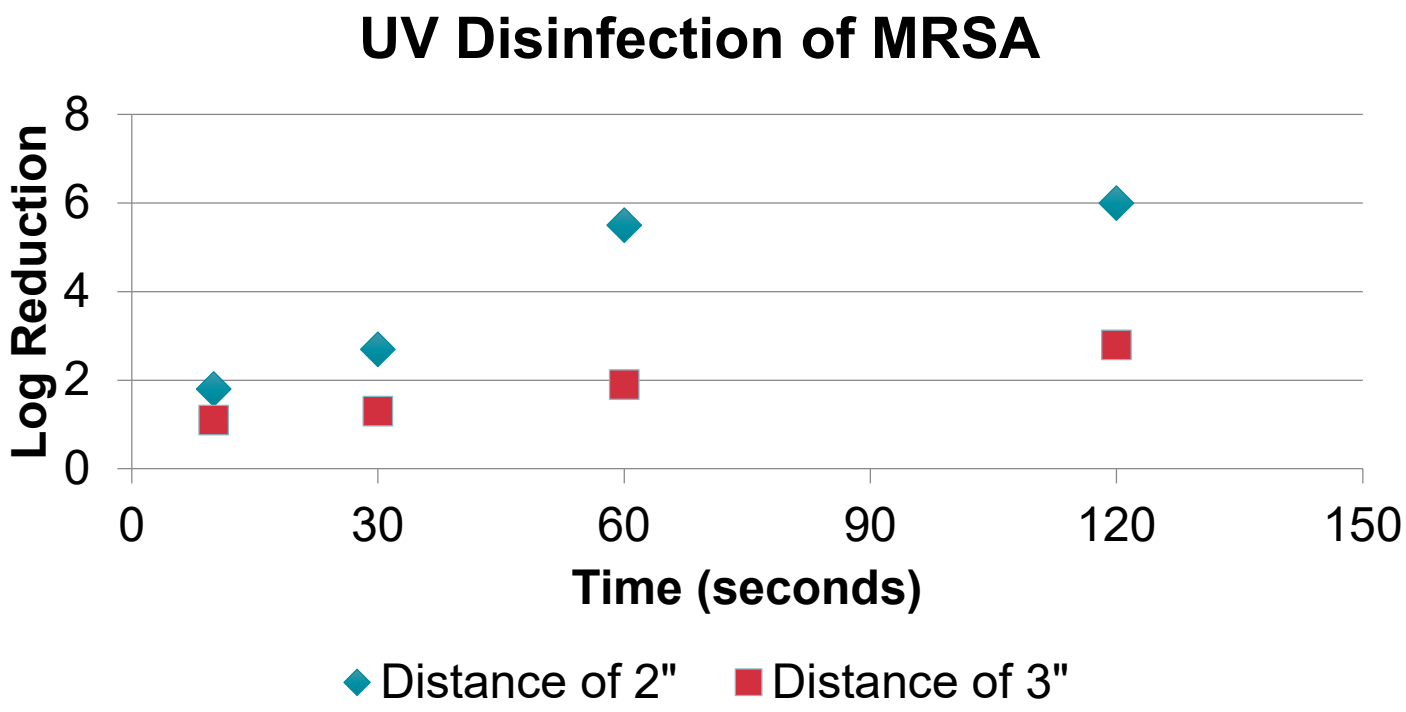
Directional emission allows for targeted disinfection.

- **Primary design considerations**
  - Size of area to be disinfected
  - Finish of the surface
  - Distance from the light source
  - Exposure time

- **Primary concerns**
  - Uniformity of irradiation
  - Lowest irradiance point
  - Time at disposal
  - Health & Safety



Balancing application goals and design



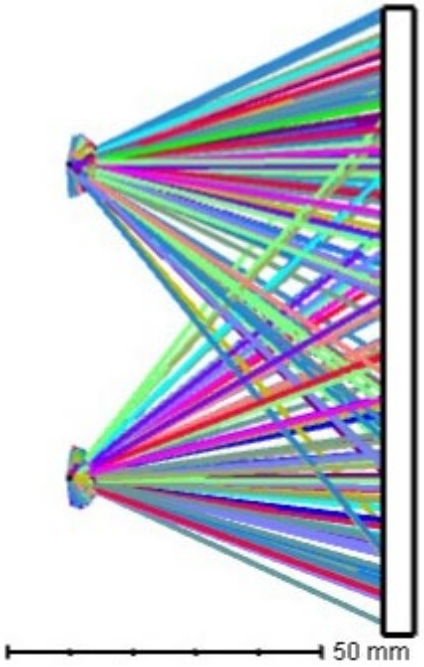
Design Engineers need to balance the intensity and exposure to meet application goals.

Variable 1: source-surface distance

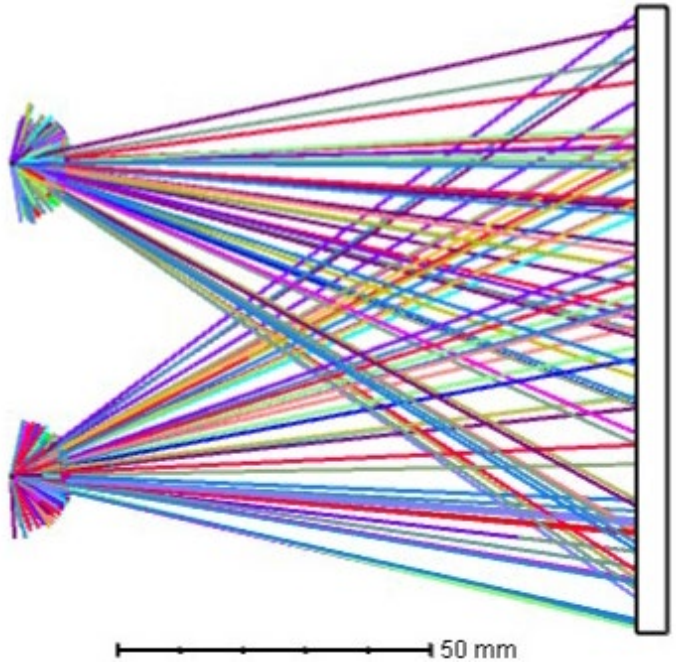
With increased distance: larger area disinfected, but less UV intensity per surface area.
In surface disinfection, the aim is for ***uniform disinfection across the surface.***

1) 20 mm

2) 50 mm

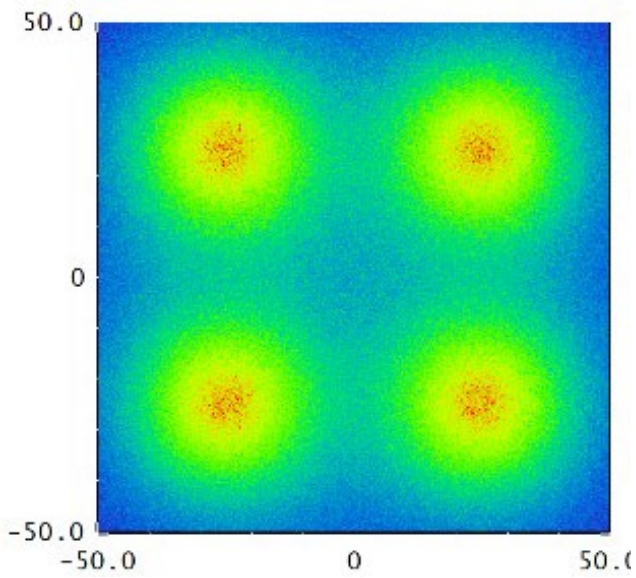


3) 100 mm



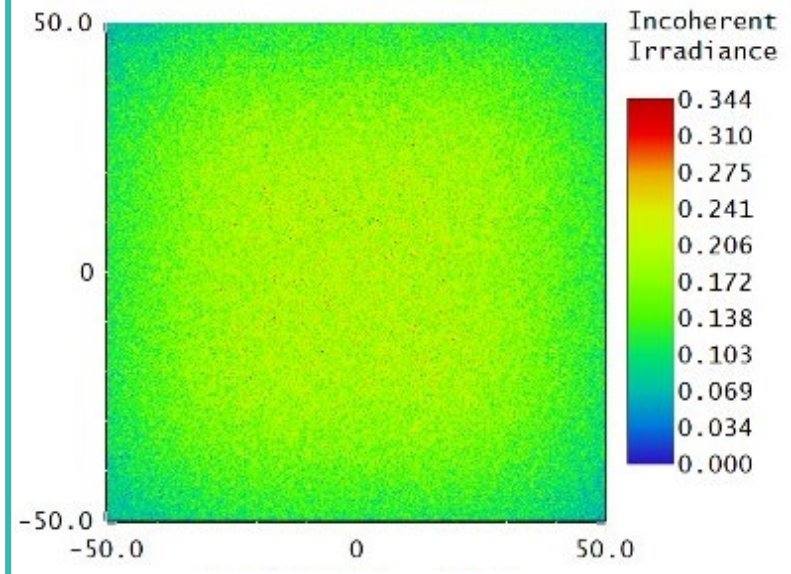
Balancing Uniformity and Dosage

1) 20 mm



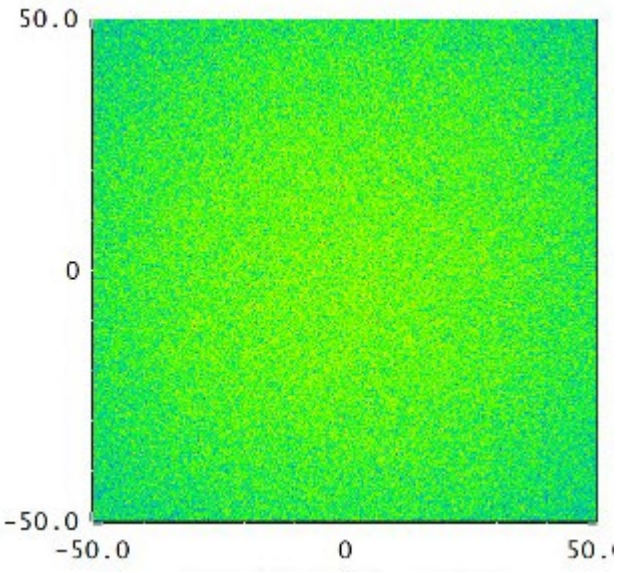
Minimum UV Intensity (corners):
0.01 mW/cm^2

2) 50 mm



Minimum UV Intensity (corners):
0.09 mW/cm^2

3) 100 mm

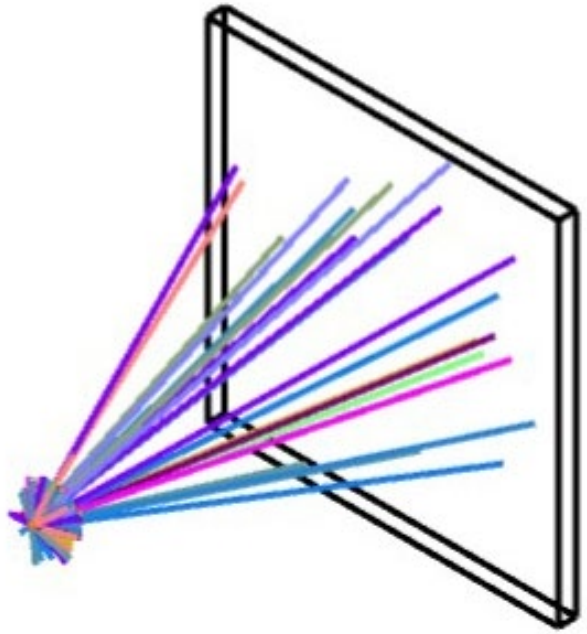


Minimum UV Intensity:
0.04 mW/cm^2

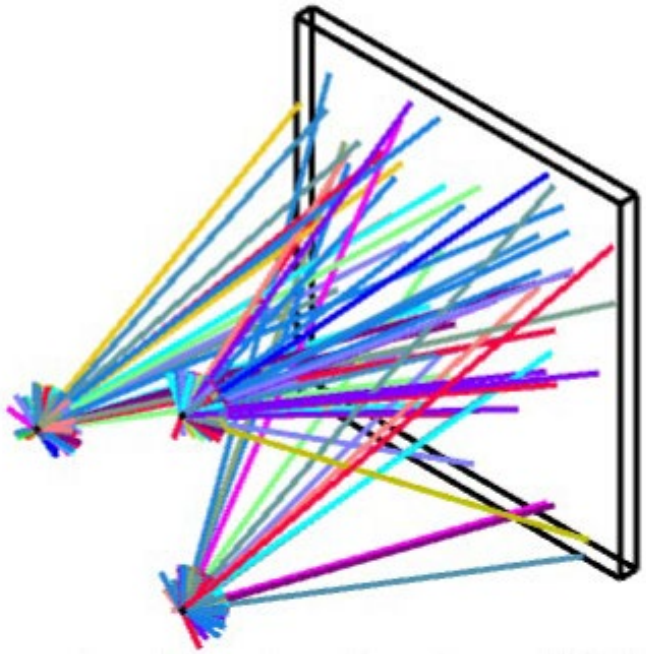
Variable 2: number of LEDs

With increased number: larger area disinfected, and higher UV intensity per surface area

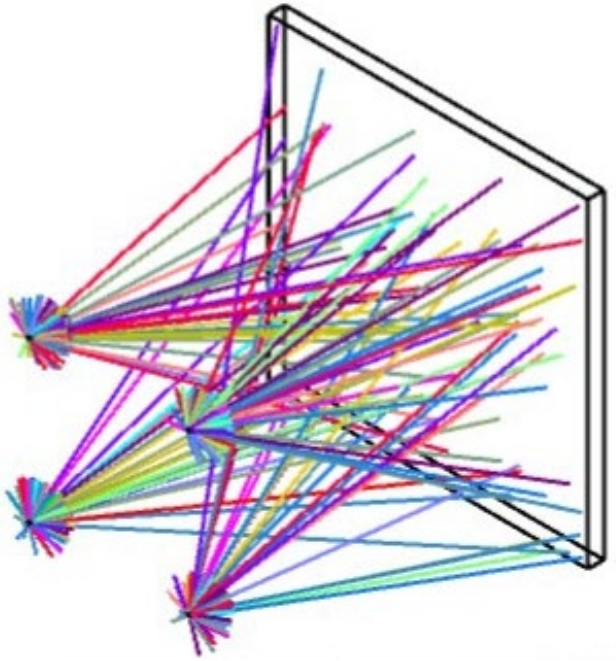
a) 1 LED



b) 3 LEDs

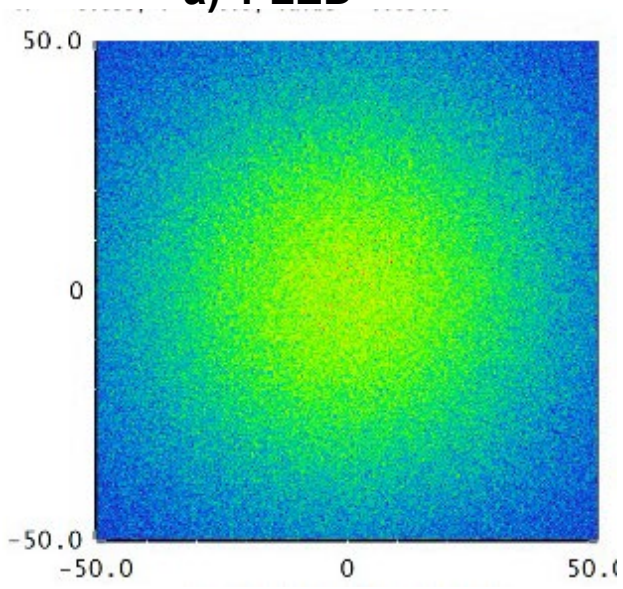


c) 4 LEDs



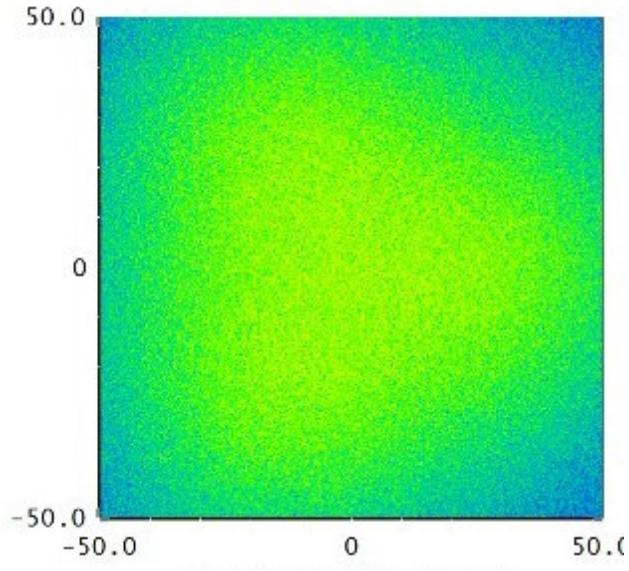
Number of LEDs Impacts Uniformity

a) 1 LED



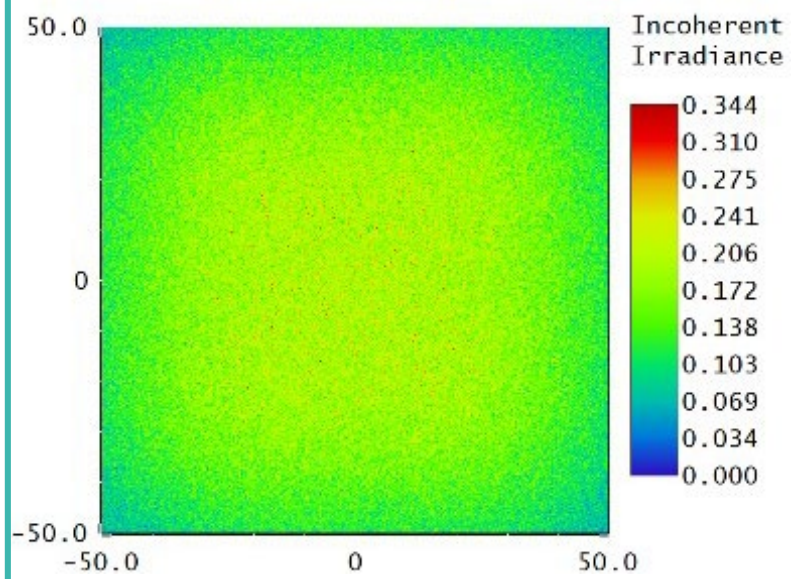
Minimum UV Intensity (corners):
0.01 mW/cm^2

b) 3 LEDs



Minimum UV Intensity (corners):
0.03 mW/cm^2

c) 4 LEDs



Minimum UV Intensity (corners):
0.09 mW/cm^2

Conclusion

- UVC LEDs can be used in the HAI's application but how you design your system is very important
- Critical items are
  - Wavelength of the light source
  - Distance to place the source
  - Uniformity of the coverage
  - Surface you are disinfecting
  - Time you have to complete disinfection
- Power and Lifetime are design variables and not absolute values

Thank You

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