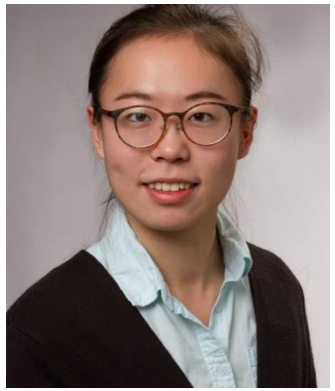
Pulsed Light's Application in the Food Safety and Enhancement Space

Louis R. Panico

Dr. Saad Ahmed



Beining Ouyang

Who are “The Pulsed Light Experts”

Louis R. Panico
CEO

XENON Corporation…

XENON Corporation designs, develops, and manufacturers full-spectrum Pulsed Light systems: an FDA-approved technology for use in food production.

The core of the system is a unique pulsed lamp manufactured by XENON and designed to maximize microorganism destruction.

What the Universe Allows….

Pulsed Light delivers very high energy pulses in extremely short periods of time.

Pulsed Light can deliver peak power 100,000 times higher than the Sun's intensity on the Earth's surface.

Continuous Light delivers low intensity levels over relatively long periods of time.

For example, delivering in 60 seconds what a single pulse can do during a duration of one (1) milli-second.

What We Do….

We design, develop, and manufacture high-performance Pulsed Lamps and related electro-optical systems.

How We Do It…

For over 50 years, XENON has perfected its expertise to enhance Pulsed Light technology and its applications.

Our unique systems combine…

- Proprietary XENON lamp technology
- Gas mixtures
- Customizable, high-speed electro-optic components

Why We Do What We Do…

… to change the way

light is used

for the **good of all**

by challenging the

status-quo.

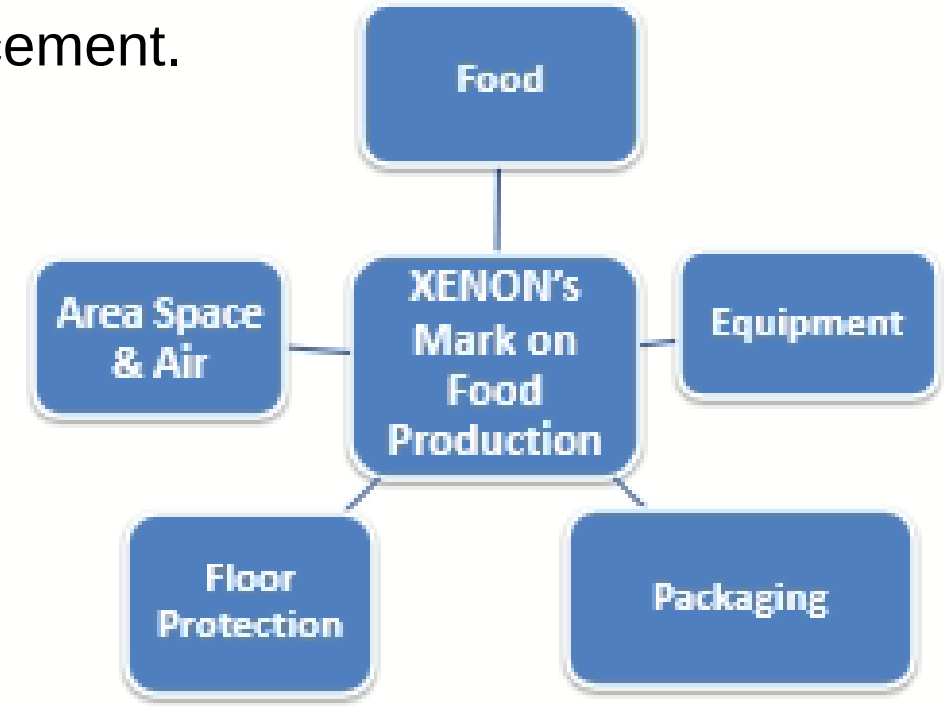
Pulsed Light and Food Production

- XENON's Pulsed Light technology is a fast, chemical-free process, delivering pathogen reduction for applications including food sanitization and enhancement, food packaging, shelf-life extension and continuous conveyor treatment.

- This webinar will include continuous conveyor treatment in the food production process. XENON pioneered this process in partnership with Cornell University's Food Technology program.

Pulsed Light in Food Production

- Food
  - Contact Surfaces | Shelf Life Extension | Enhancement.
- Equipment
  - Any-time Conveyor Treatment.
- Packaging
  - On-line Sanitization Sheet | Finished Packages
- Floor Protection
  - Shoe Sanitization at Food Production Plants.
- Area Space & Air
  - Robotic and/or Fixed Position



Z-2000: Conveyor Decontamination System

Food-grade controller and lamp housings designed to meet IP67 and NEMA 4X standards.

Chemically Free Dry Zap (Clean Beam LLC)

Pulsed Light effectively eliminates harmful bacteria and other viruses to sanitize footwear between sterilized and uncontrolled environments; ensuring food remains safe and people stay healthy.

Combatting Covid-19

- XENON pulsed UV lamps are at the heart of a revolutionary product being used for space sanitization in hospital-rooms, airports, trains and many more.
- Currently, there are more than 2,100 systems in use worldwide at over 600 hospitals.
- A single unit kills bacteria and viruses on exposed surfaces in approximately 5 minutes.
- This replaces the use of many hazardous chemicals and/or use of traditional UV lamps which contain Mercury and take up to 5-10 times longer.

Bio Effectiveness of Pulsed Light

Dr. Saad Ahmed

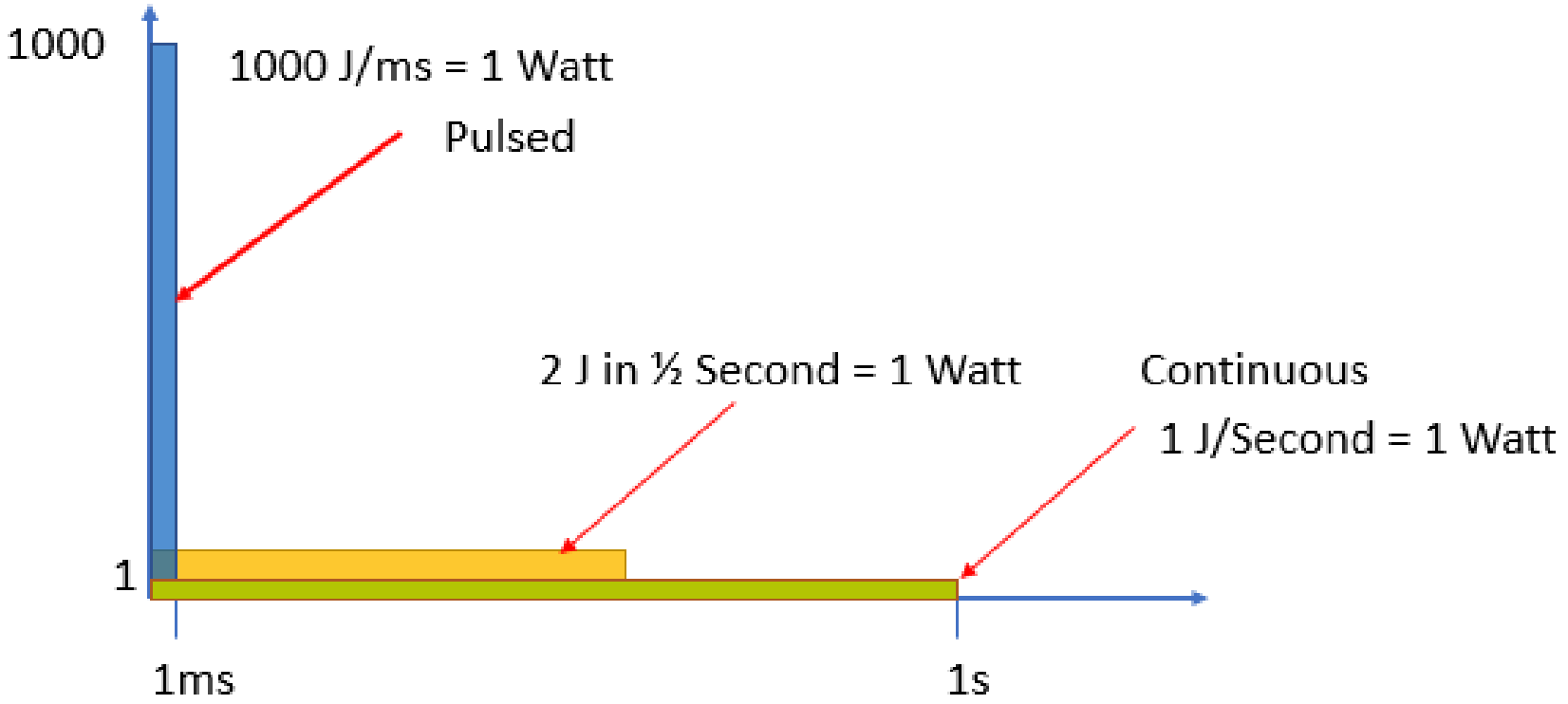
Vice President of Operations

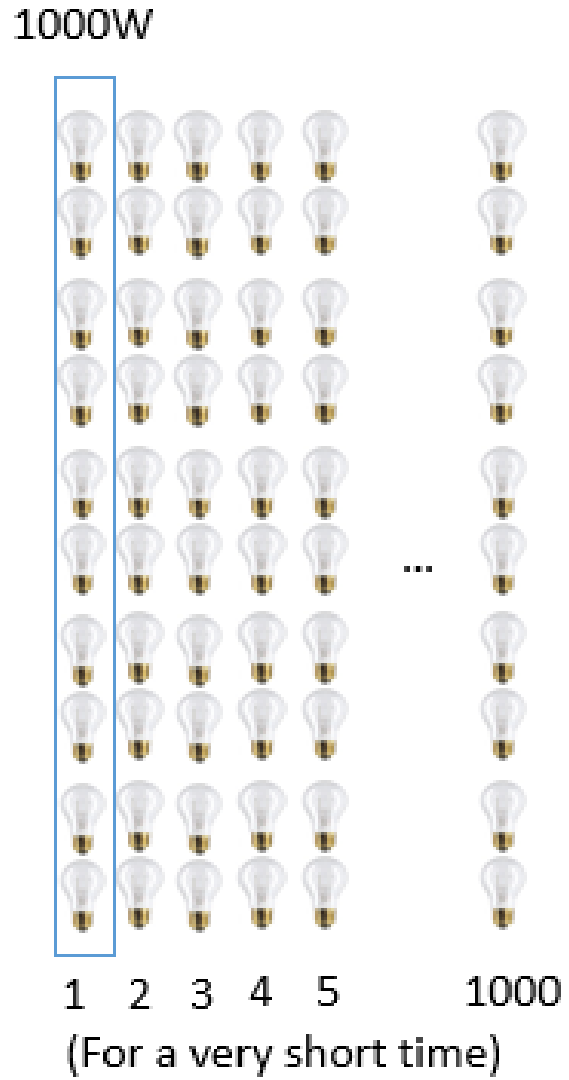
A Comparison of Light Sources

Xenon Pulsed Lamp	Incandescent Bulb	Mercury Lamp
1000W	100W	100W
Gas Discharge (Xenon)	Filament Heating	Mercury Vapor Excitation
High Voltage (1-10KV)	Mains Driven (110V)	Mains Driven (110V) Ballast
Broad Spectrum UV Rich	Visible and IR	UV
Instant On/Off	Some Time	Time to Heat Up
Inert (Safe) No Mercury	Inert	Contains Mercury
Pulsed	Continuous	Continuous

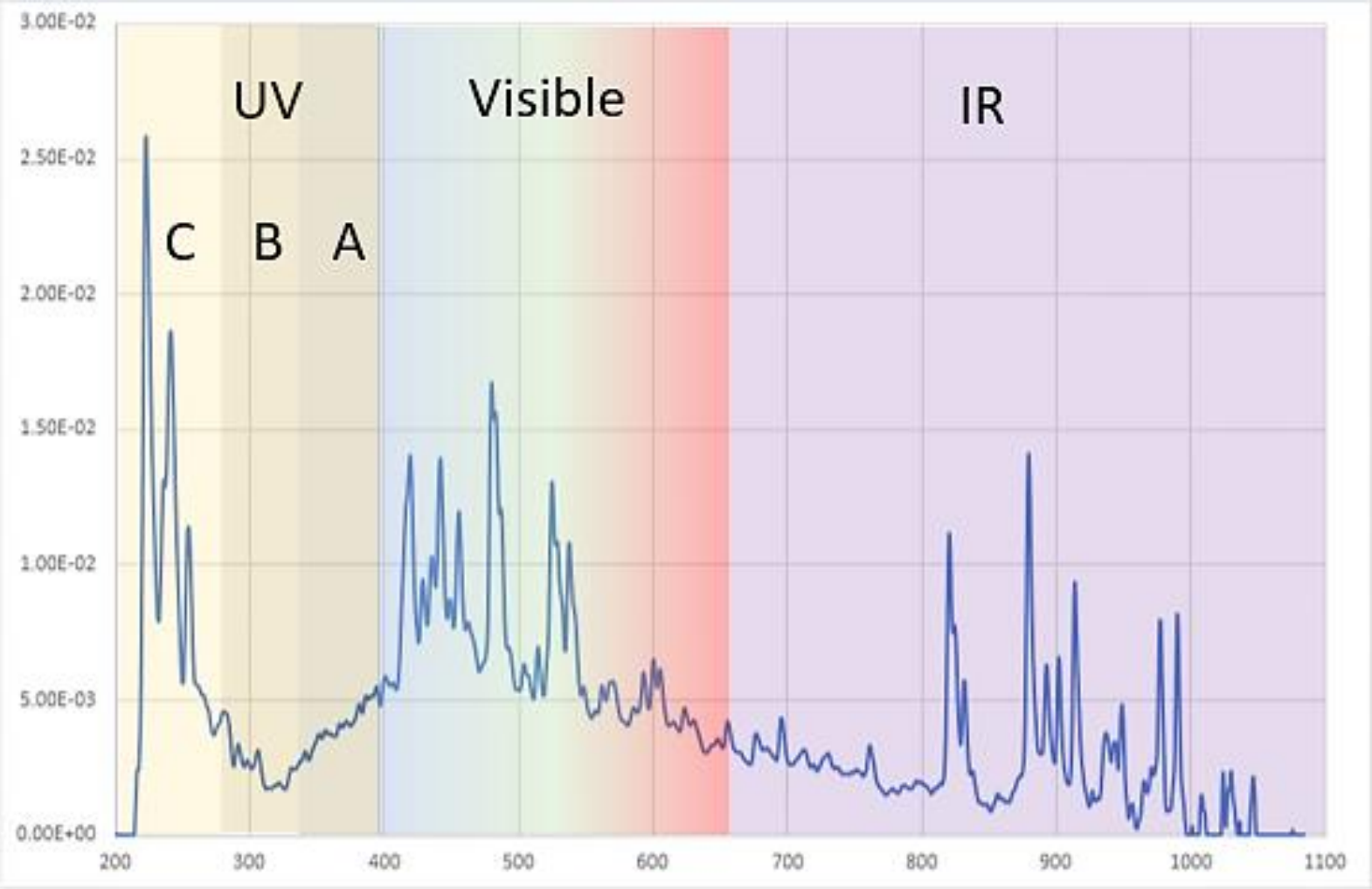
Pulsed Light and Peak Power

- By storing the energy in time we can make the light more intense
- Typical pulse durations for flash lamps is around 1ms
- For a 1000W the peak energy is 1MegaWatt Peak Power





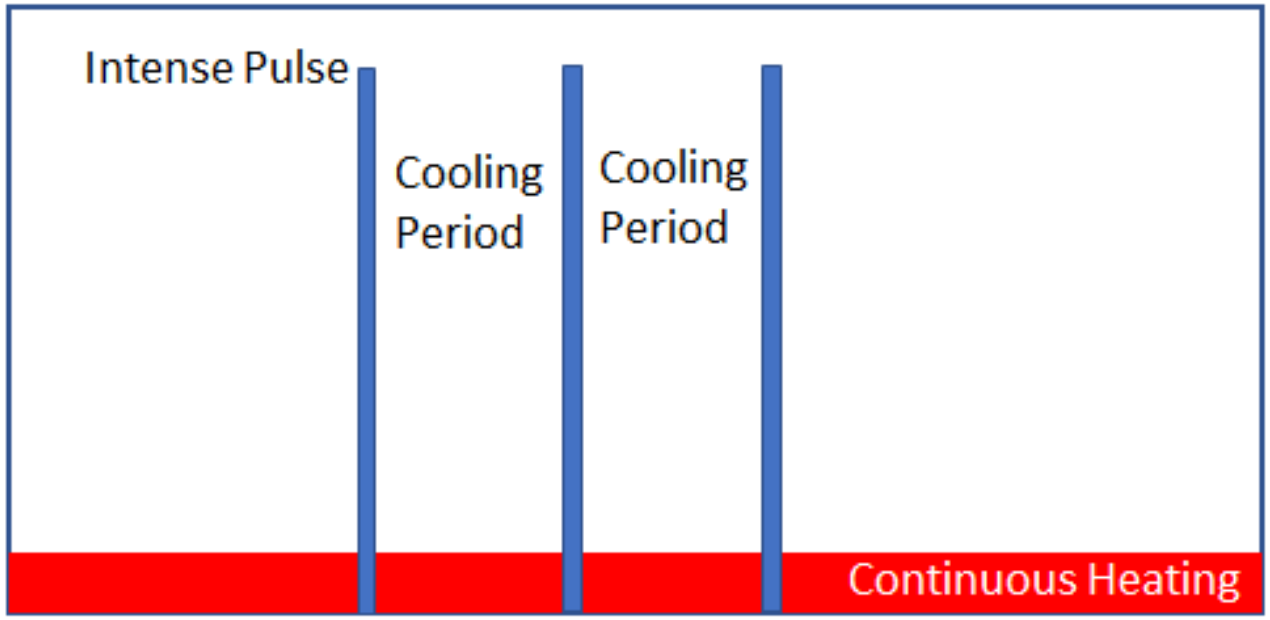
The Xenon Gas Broad Spectrum: Deep UV to Visible



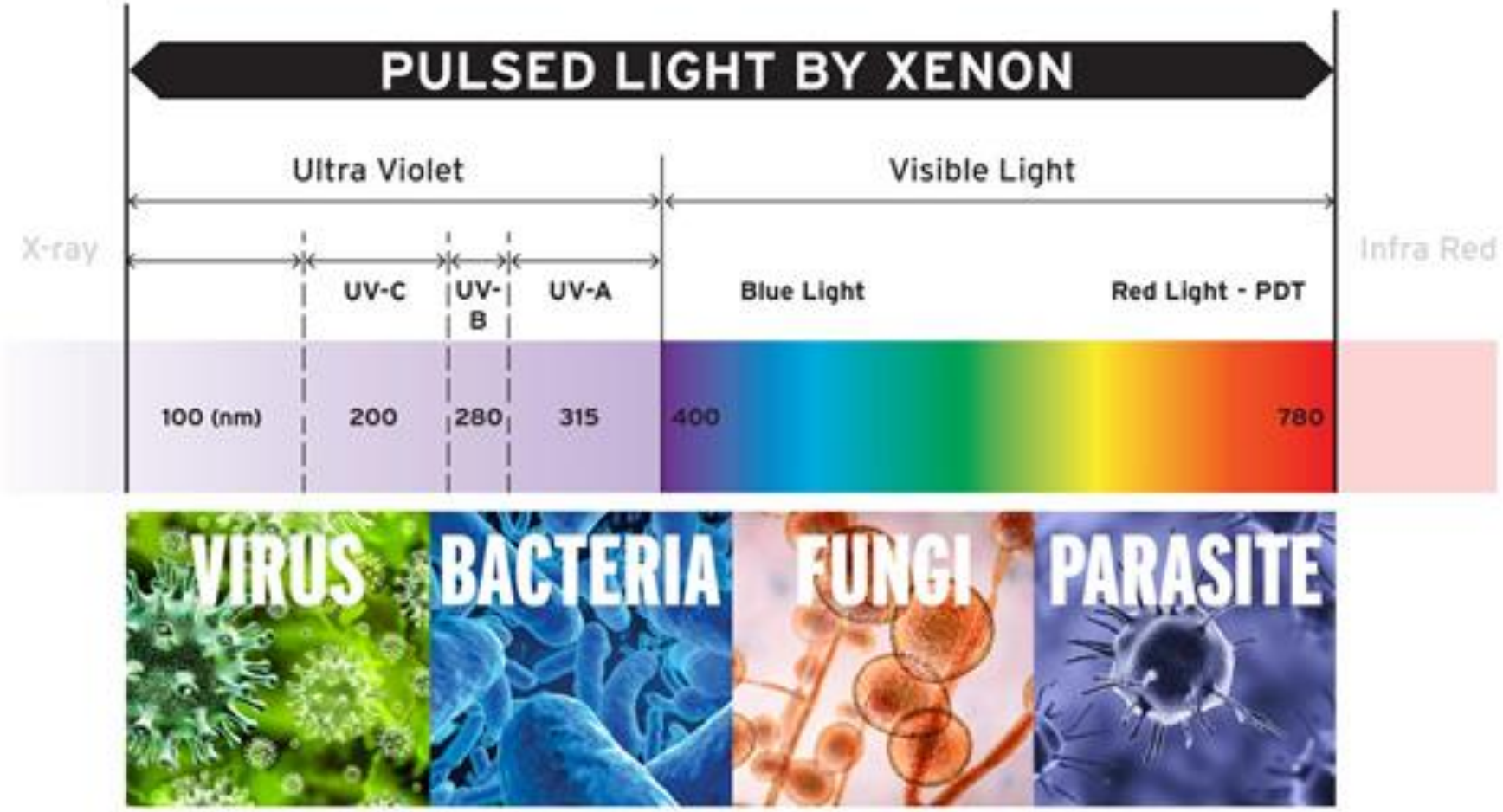
- Rich in UV with high-energy photons that can kill microorganisms.
- Nearly identical to the spectrum of sunlight but with higher intensity.

XENON is a Cooling Technology

- By controlling the pulse frequency, we can allow the target to cool.
- Pulse on time may be thousandths of a second.
- High-energy pulses means we get an effective kill.
- Very little temperature rise on the surface (food/package/conveyor).

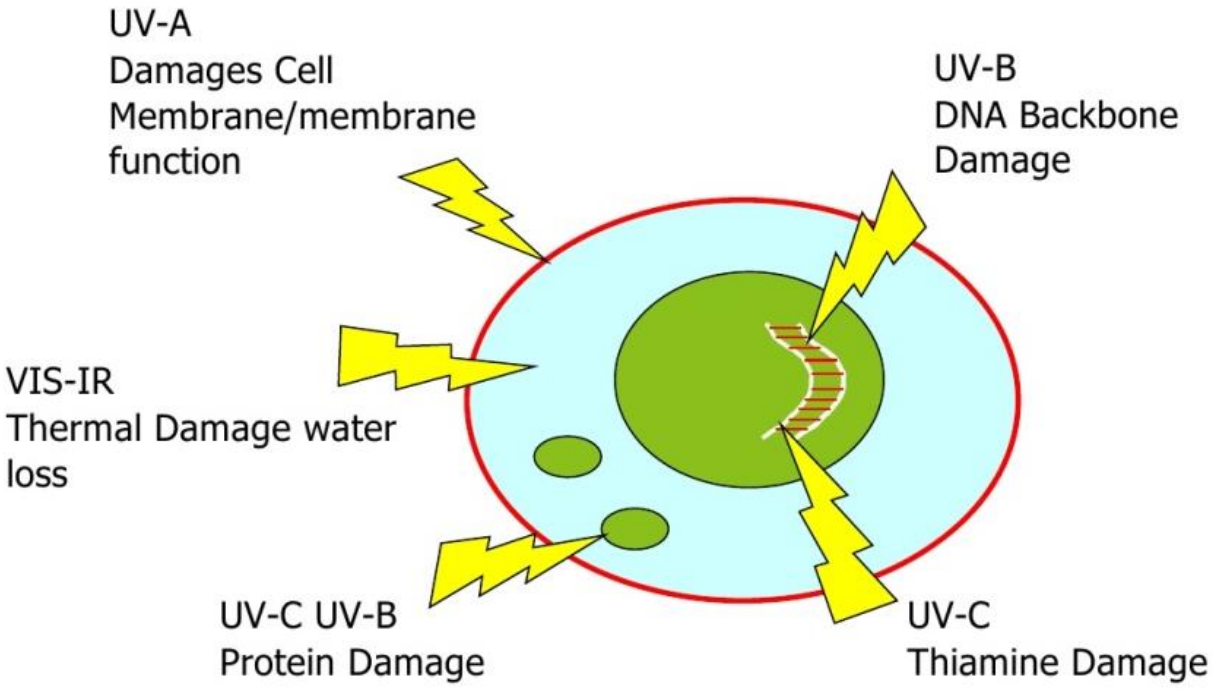


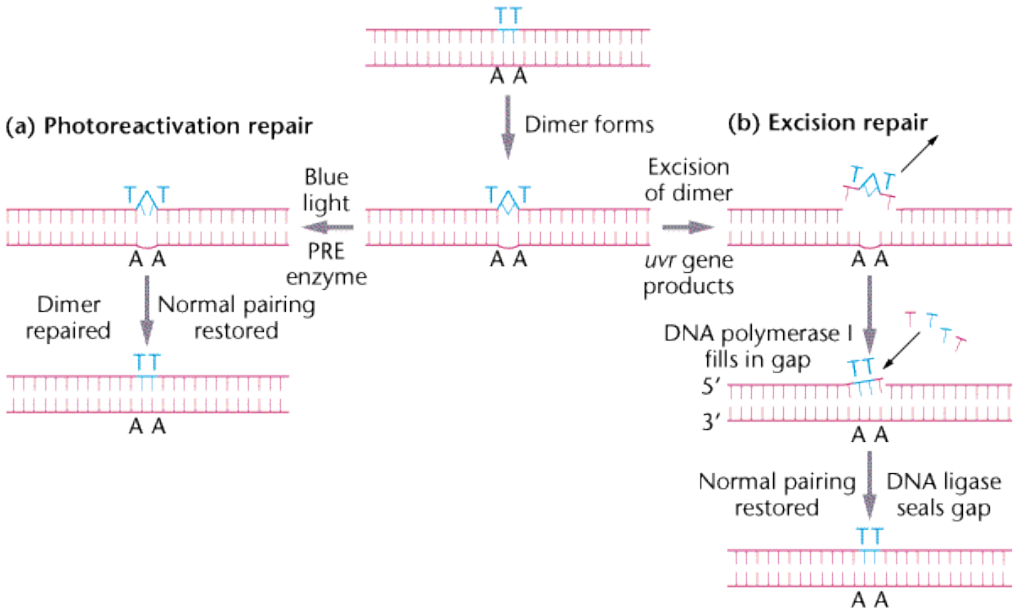
Organism Susceptibly to the Visible Spectrum



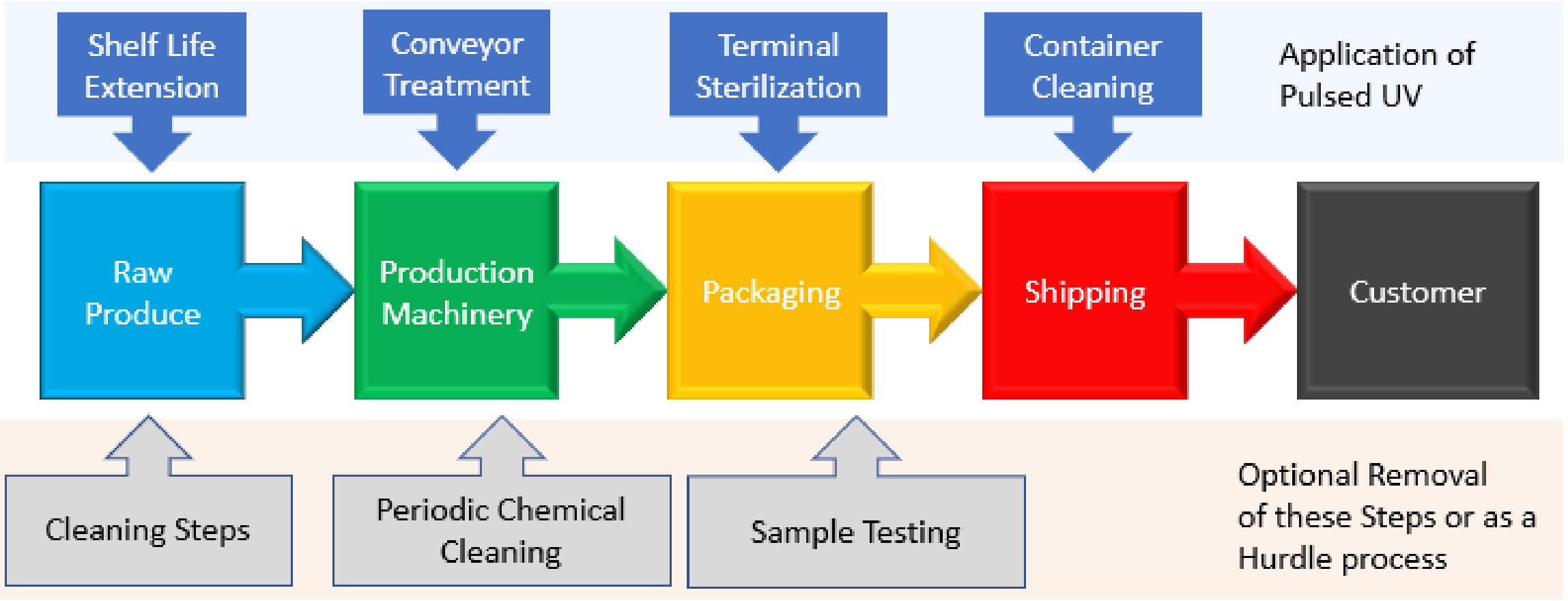
Multi-pathway Extinction Based on Spectra

- Different parts of the XENON spectrum can damage cells in multiple ways.
- High-peak energies can penetrate cells deeply and kill more effectively.
- Pulsed Light overpowers the cell repair mechanisms (Enzymatic Photoreactivation).





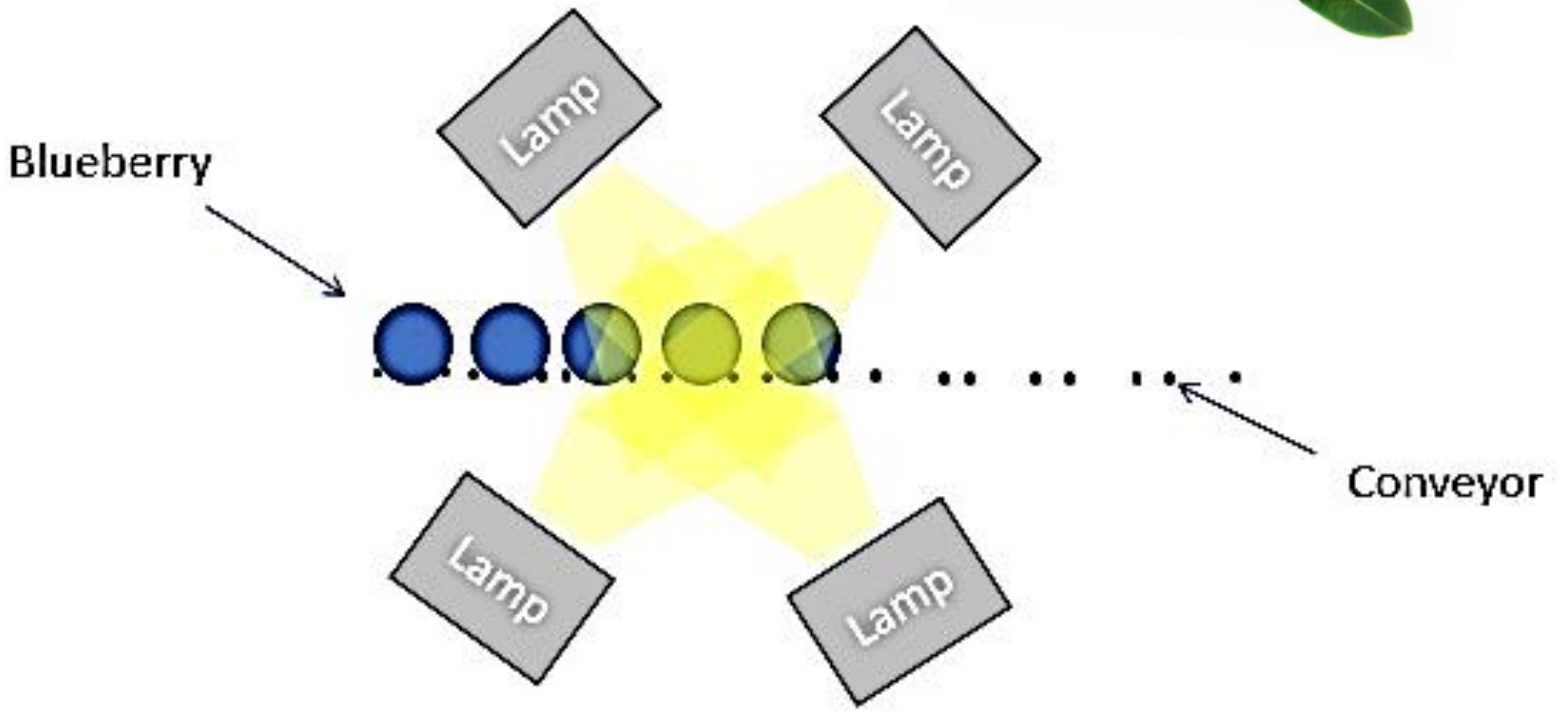
Pulsed Light in the Food Industry



Shelf-life Extension: Blueberries

Blueberries have limited shelf-life because of exposure to surface contaminates.

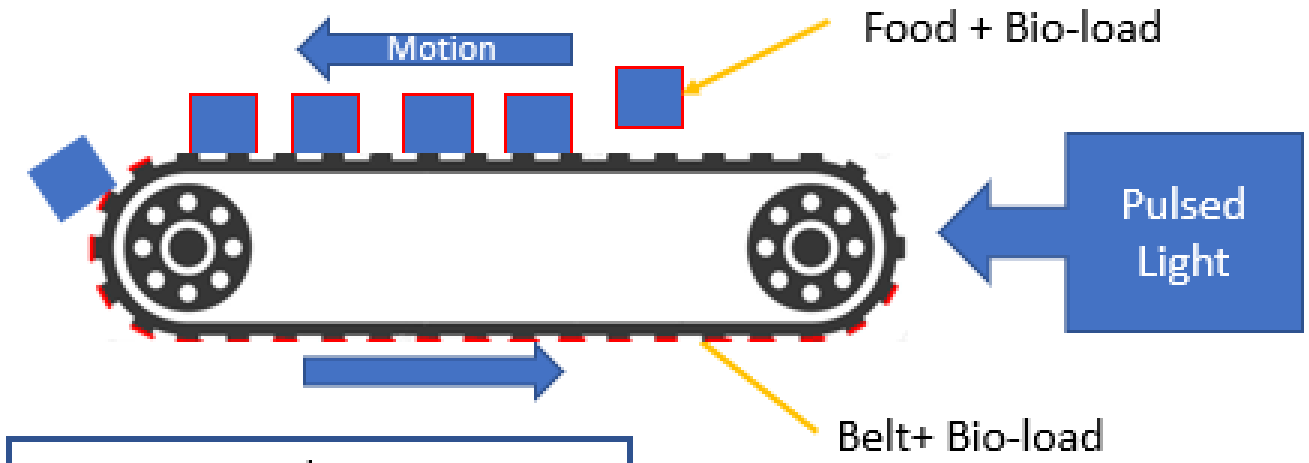
Many fruits and vegetables have been proven to have their shelf-life extended through exposure to Pulsed Light.

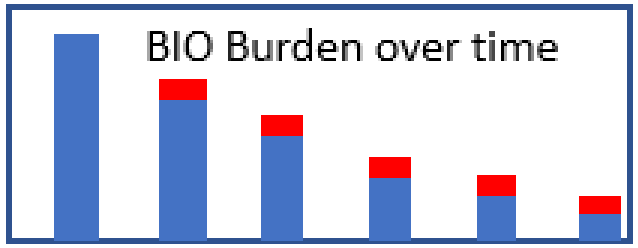


Foods treated with Pulsed Light are not only safer, but they stay fresh longer.

Conveyor Treatment

Continuous Pulsed Light treatment on production conveyors eliminates the need for regular washdowns; reducing the bio load on the conveyor.





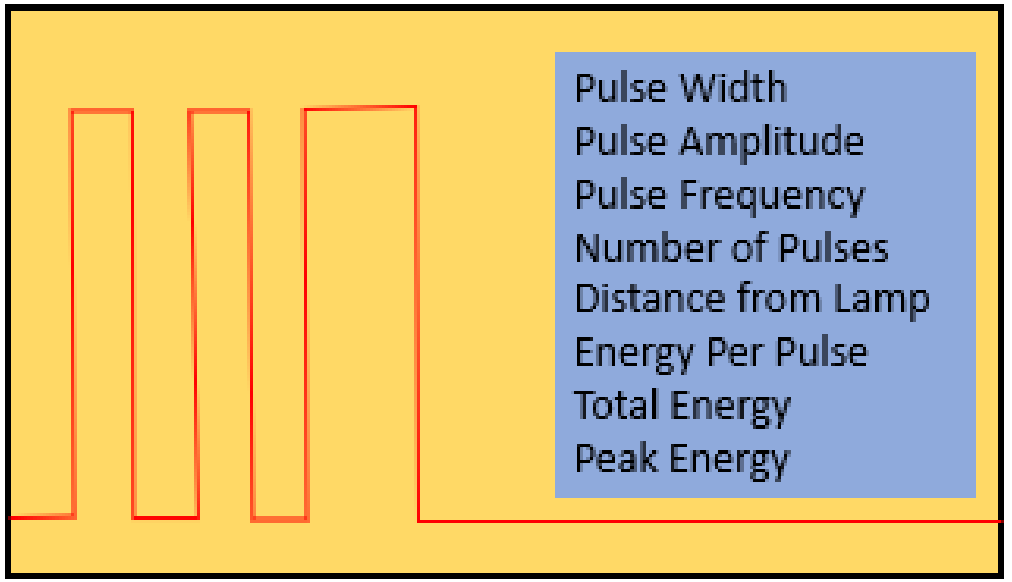
Each Revolution the bio-load at any spot is reduced

Pulsed Light Terminal Sterilization

After packaging, products can be treated with Pulsed Light if the packaging is UV transmissive.

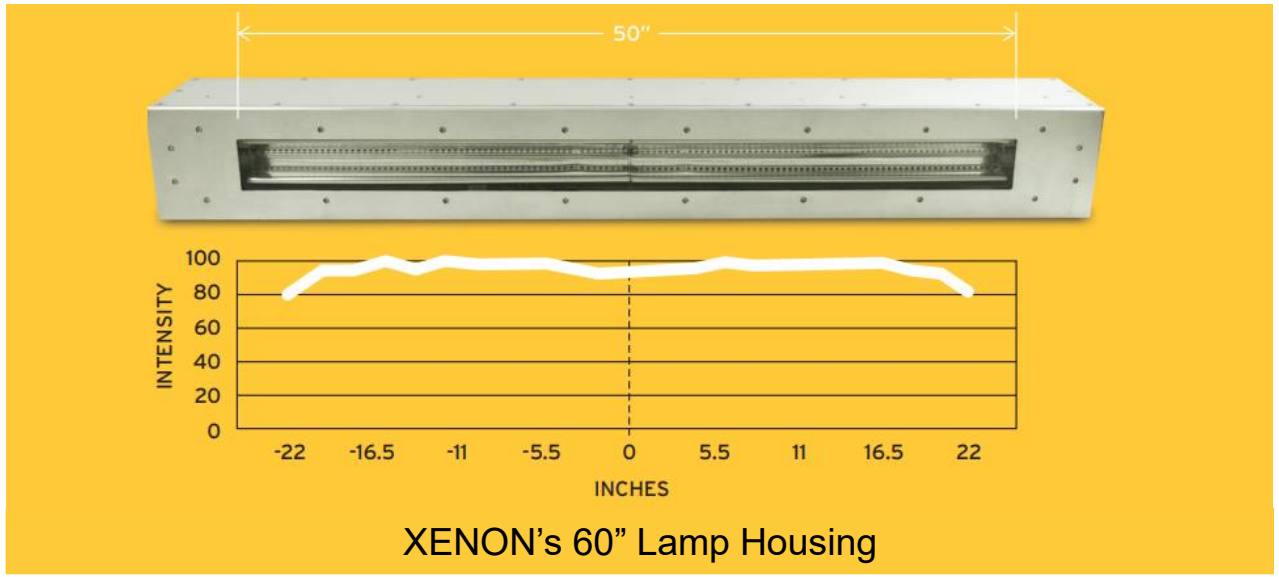
Solution for Food R&D

A versatile system to test the optimal parameters for food safety.



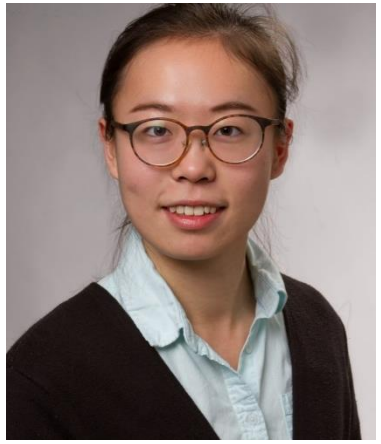
Shipping Containers, Storage Spaces and COVID-19

- Shipments carrying produce from high-risk locations are suffering from the fear associated with Covid-19.
- XENON's Pulsed Light sanitization and decontamination technology could provide the solution.



XENON's 60" Lamp Housing

Decontamination Effect of XENON Pulsed UV Light

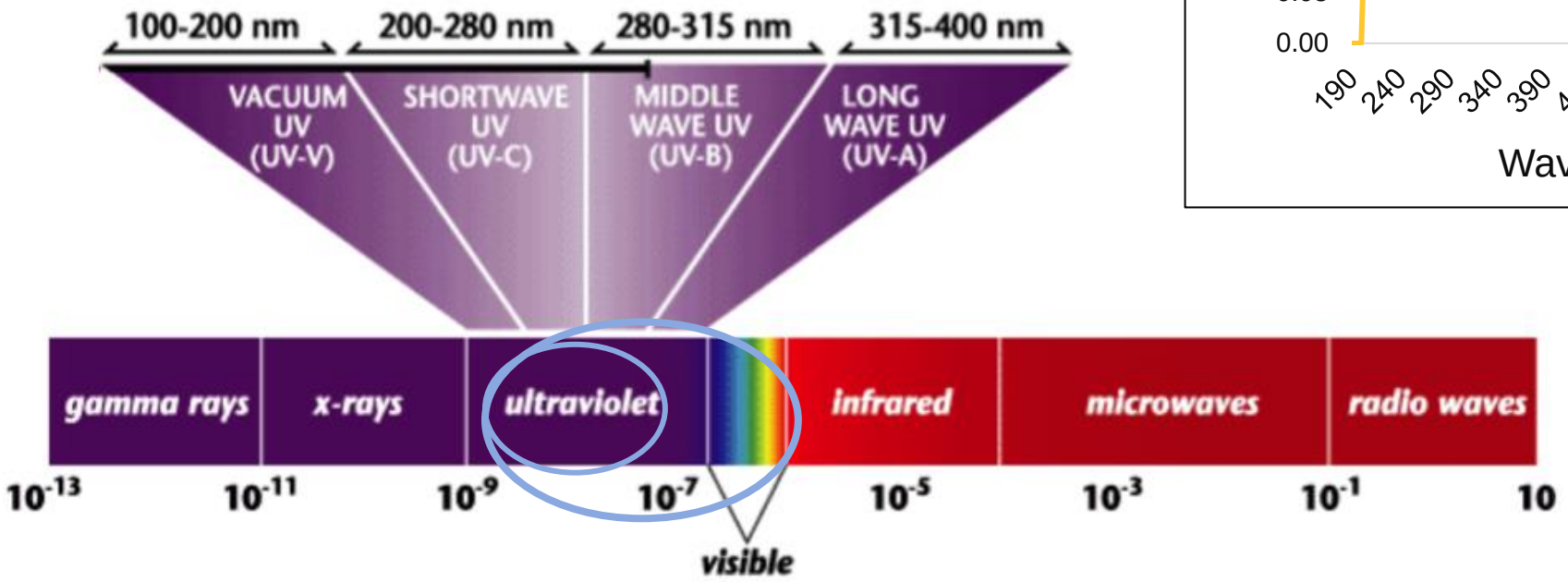


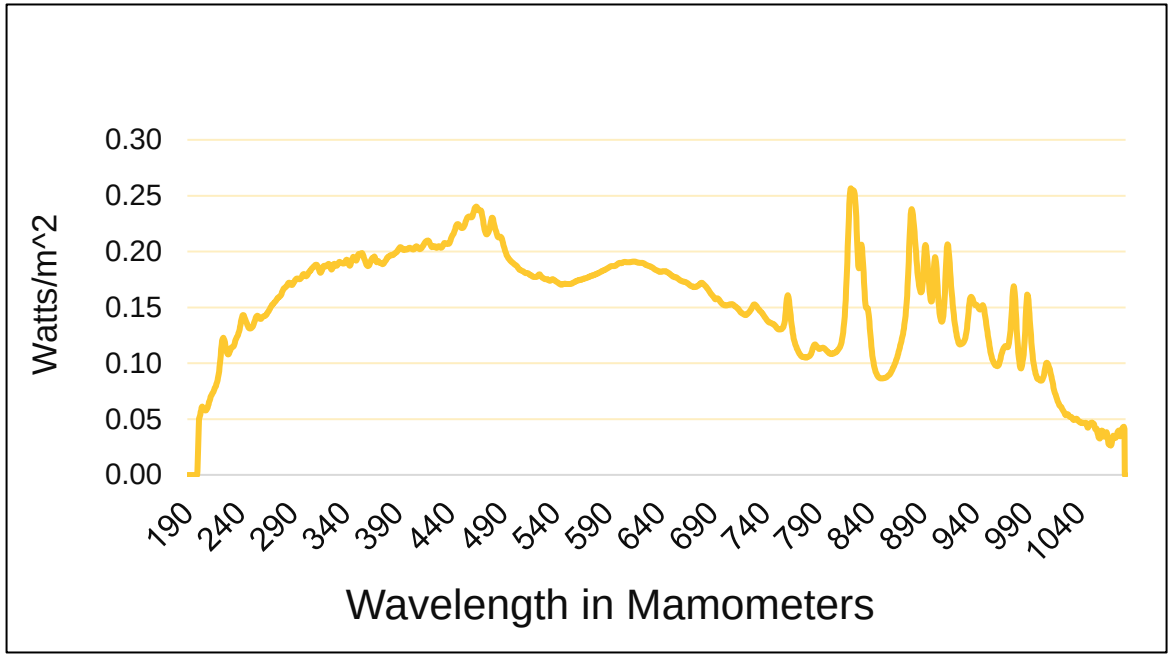
Beining Ouyang

Microbiologist

Pulsed Light Spectrum

- Conventional UV light: 100-400 nm
- Pulsed light: broader spectrum (100 – 1100 nm)





Mechanism of Pulsed Light on Bacteria

Photo-chemical

DNA damage

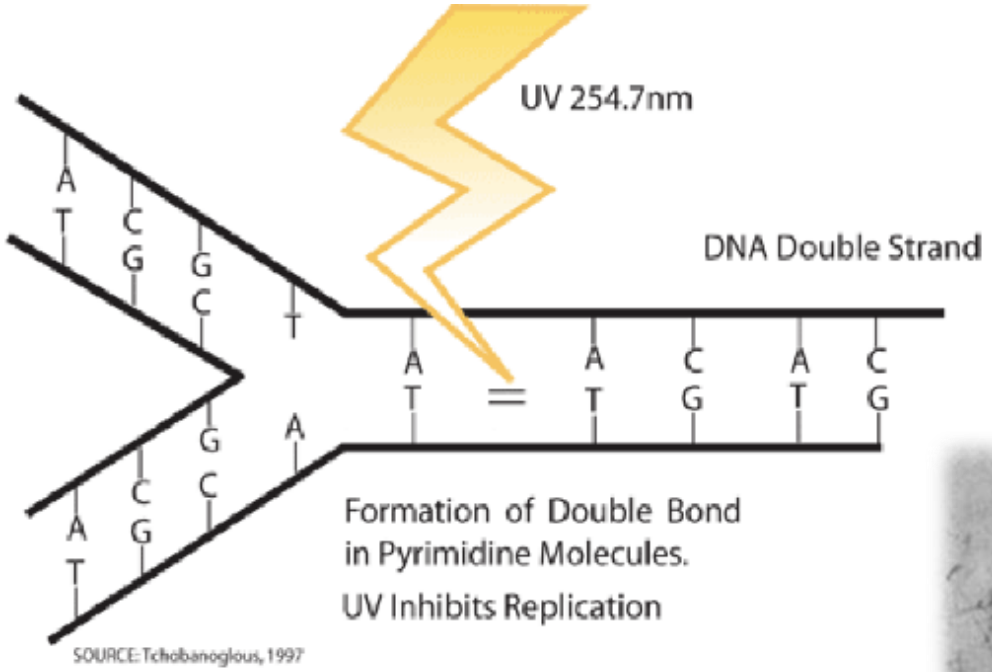
Thermal Shock

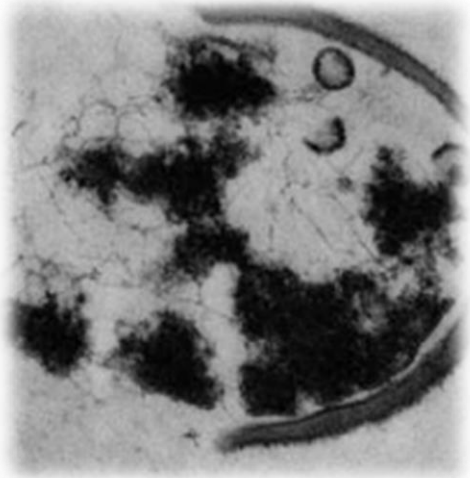
Localized heating

at the cellular membrane

Physical

Micro-vibrations

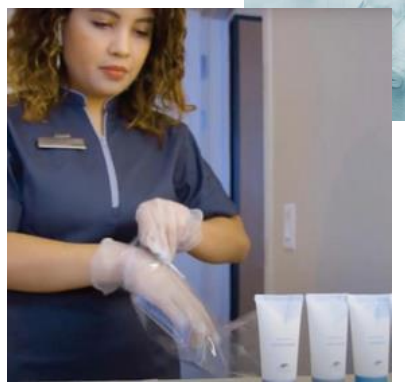




(Krishnamurthy et al. 2010)
S. Aureus after pulsed UV light: cell rupture and cellular content leakage

Applications

- Air Sanitization
  - Room Cleaning
    - Hospital
    - Hotel
    - Office…
  - Dynamic air
- Surface & Food Packaging Materials
  - Stainless steel
  - Cutting boards
  - Trays
  - Aluminum trays…



Products for Different Needs

RC-800/900 Modular System

Modular units designed for OEM applications.

The Z-2000 Conveyor Decontamination System

Food-grade controller and lamp housings designed to meet IP67 and NEMA 4X standards.

The X-1100 Benchtop Research System

The XENON X-1100 is the only low-cost benchtop Pulsed Light system that enables researchers to more easily characterize new processes using XENON's proven technology.

Decontamination Effect of XENON Pulsed UV Light

It has been reported that XENON flash lamps can kill *Staphylococcus aureus, Escherichia coli* O157:H7*, B.pumilus, Salmonella*, and *Listeria*…

XENON System	Microorganism	Substrate	Maximum Log reduction
XENON Pulsed Light System	Staphylococcus aureus	High-touch surfaces in a hospital	Decreased Methicillin-resistant Staphylococcus aureus abundance by 72.1% compared with manual cleaning [1]
STERIPULSE® XENON RS-3000C	Listeria innocua	Cheese surface	3 log reduction after exposure to 6 J/cm^2. [2]
XENON STERIPULSE®	Escherichia coli	Liquid media	12-15 pulses achieved a minimum 4 log reduction on the top tray [3]

[1] Kitagawa, Hiroki, et al. "Effect of pulsed xenon ultraviolet disinfection on methicillin-resistant Staphylococcus aureus contamination of high-touch surfaces in a Japanese hospital." *American Journal of Infection Control* 48.2 (2020): 139-142.
[2] Proulx, J., et al. "Pulsed-light inactivation of pathogenic and spoilage bacteria on cheese surface." *Journal of dairy science* 98.9 (2015): 5890-5898.
[3] John, Dalia, and Hosahalli S. Ramaswamy. "Comparison of pulsed light inactivation kinetics and modeling of Escherichia coli (ATCC-29055), Clostridium sporogenes (ATCC-7955) and Geobacillus stearothermophilus (ATCC-10149)." *Current Research in Food Science* (2020).

Decontamination Effect of XENON Pulsed UV Light

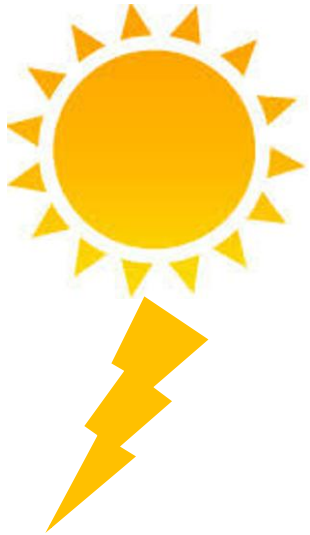
Scientific Research at XENON
Log reduction data on hard Surfaces

The X-1100 Benchtop Research System

Microorganism	Voltage (V)	Electrical Energy (J)	Optical reading	distance (inches)	Pulse number	Log reduction	Std
E.coli K12 on Aluminum foil (1 x 3 inch)	3000	1000	2.19 J/pulse/cm^2	2	1	**3.08**	0.19
	3000	800	1.627 J/pulse/cm^2	2	1	**2.72**	0.2
	3000	300	0.513 J/pulse/cm^2	2	1	**2.18**	0.95
	2000	1000	1.050 J/pulse/cm^2	2	1	**3.07**	0.37
	2000	800	1.050 J/pulse/cm^2	2	1	**2.47**	1.34
	2000	300	0.526 J/pulse/cm^2	2	1	**2.04**	1.16

Enhancement of Vitamin D in Mushrooms

Ergosterol (provitamin D_2)



UV

Use XENON's Pulsed Lamps to Boost Vitamin D in Mushrooms.

Vitamin D_2

Ergosterol (provitamin D2) in mushroom can be converted to Vitamin D2 by pulsed light in seconds.

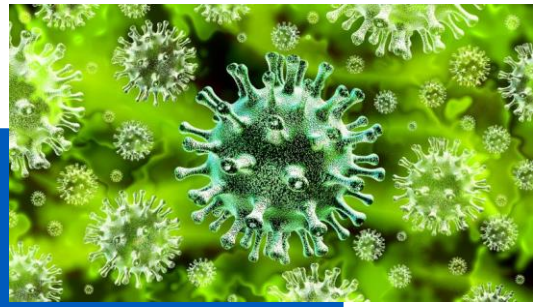
XENON™

Enhancement of Vitamin D in Mushrooms

XENON System Used	Mushroom	Result
STERIPULSE® 3000 Pulsed 	Fresh Button Mushrooms	Vitamin D2 was found to increase to over 100% Daily Value after 3 pulses (1 s) [4]
	Oyster Mushrooms	Vitamin D2 increased from initial level of 15% DV/serving to 1618% DV/serving after 3 pulses [5]
	Shiitake Mushrooms	3% DV/serving to 490% DV/serving after 1 pulse [5]

[4] Kalaras, Michael D., Robert B. Beelman, and Ryan J. Elias. "Effects of postharvest pulsed UV light treatment of white button mushrooms (Agaricus bisporus) on vitamin D2 content and quality attributes." *Journal of agricultural and food chemistry* 60.1 (2012): 220-225.
[5] Kalaras, Michael D., and Robert B. Beelman. "Vitamin D2 enrichment in fresh mushrooms using pulsed UV light." *Available online at: foodscience. psu. edu/directory/rbb6/VitaminD Enrichment. pdf* (2008).

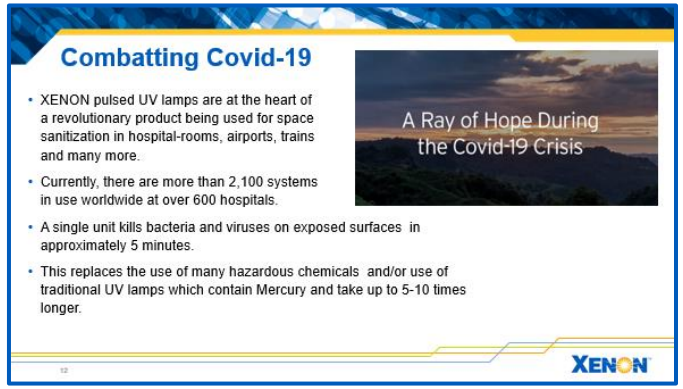
Pulsed Light Can Kill Covid-19 Virus



Paper Title	Log Reduction
Deactivation of SARS-CoV-2 with Pulsed-xenon Ultraviolet Light: Implications for Environmental COVID-19 Control (Simmons et al. 2020)	For hard surfaces, disinfection for 1, 2, and 5 minutes resulted in 3.53 log_{10}, >4.54 log_{10}, and >4.12 log_{10} reductions in viral load, respectively. For N95 respirators, disinfection for 5 minutes resulted in >4.79 log_{10} reduction in viral load.

Combatting Covid-19 with Pulsed Light

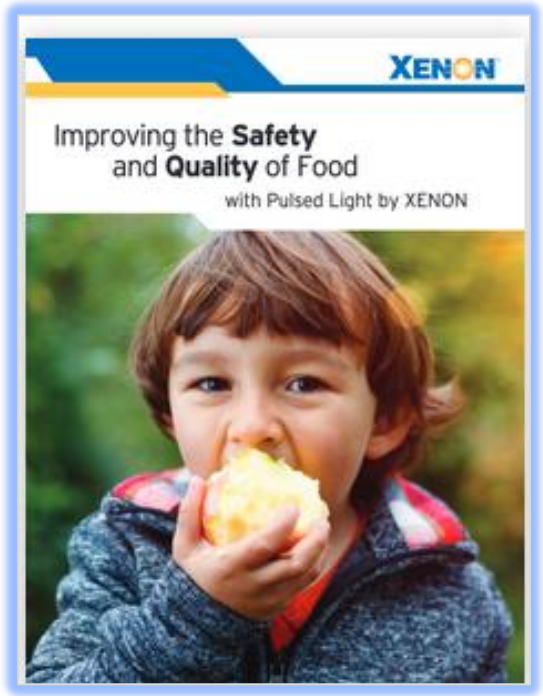
VIDEO PLAYS HERE – THIS SLIDE



XENON Resources…

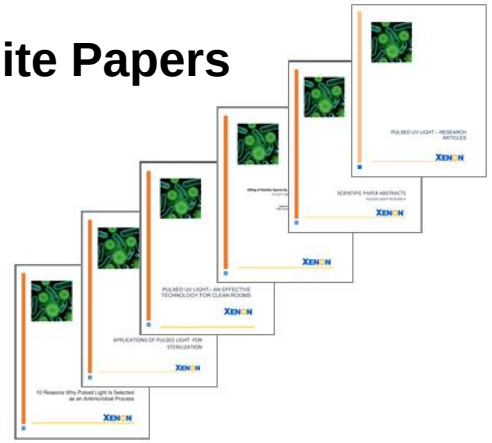
Kindly complete our brief survey and receive access to our wealth of knowledge including our "***Improving the Safety and Quality of Food***" Brochure created for you – our webinar viewers.

Improving the Safety and Quality of Food Brochure



Application Sheets

White Papers



Cited Sources

Product and Data Sheets

Thank you!

XENON Corporation
37 Upton Drive,
Wilmington, MA 01887

xenoncorp.com

marketing@xenoncorp.com

Questions

Q&A with Our Team:

Louis Panico

Dr. Saad Ahmed

Beining Ouyang