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# The Science & Validation of Radiation Processing

***August 2025***

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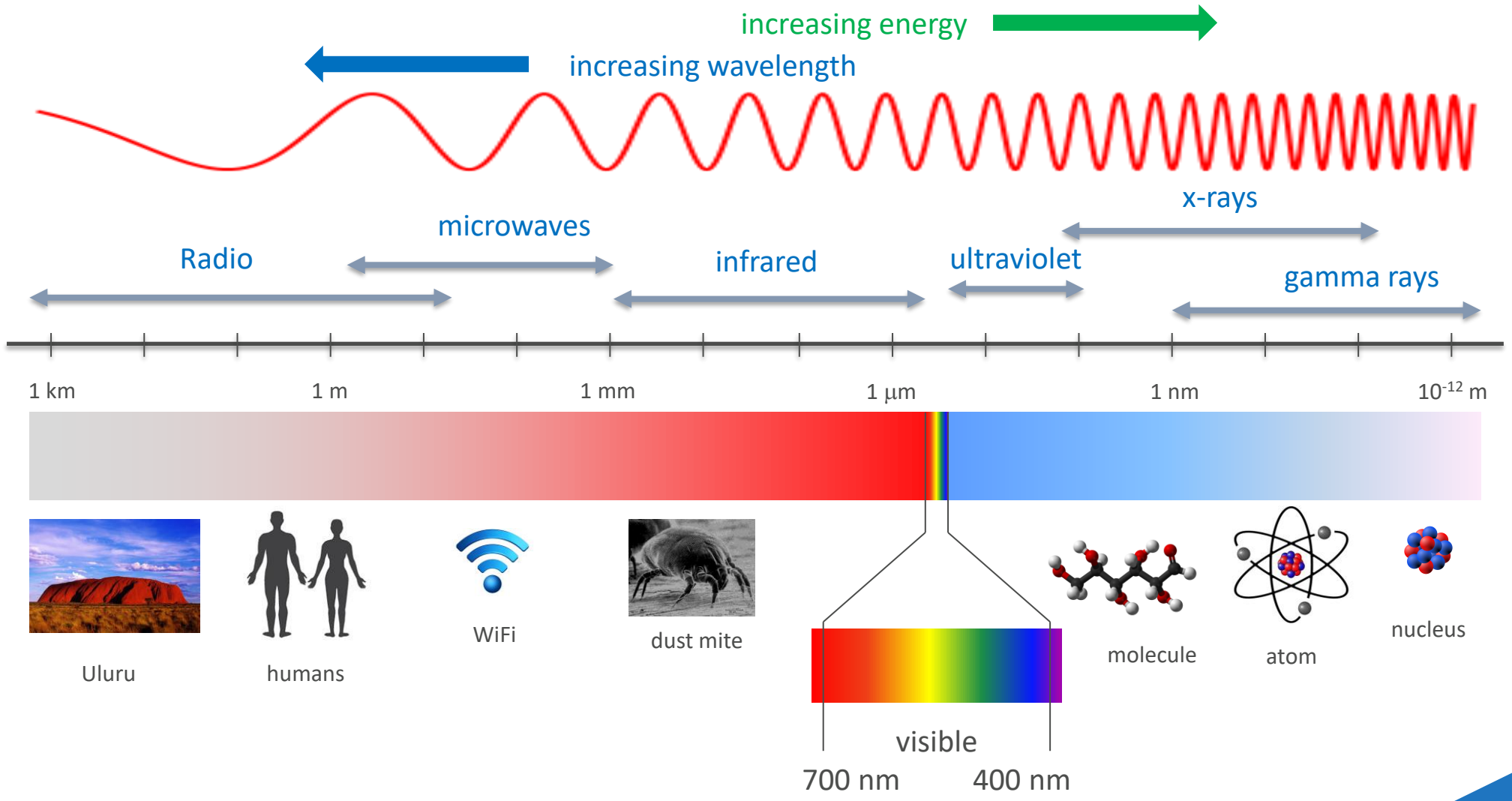
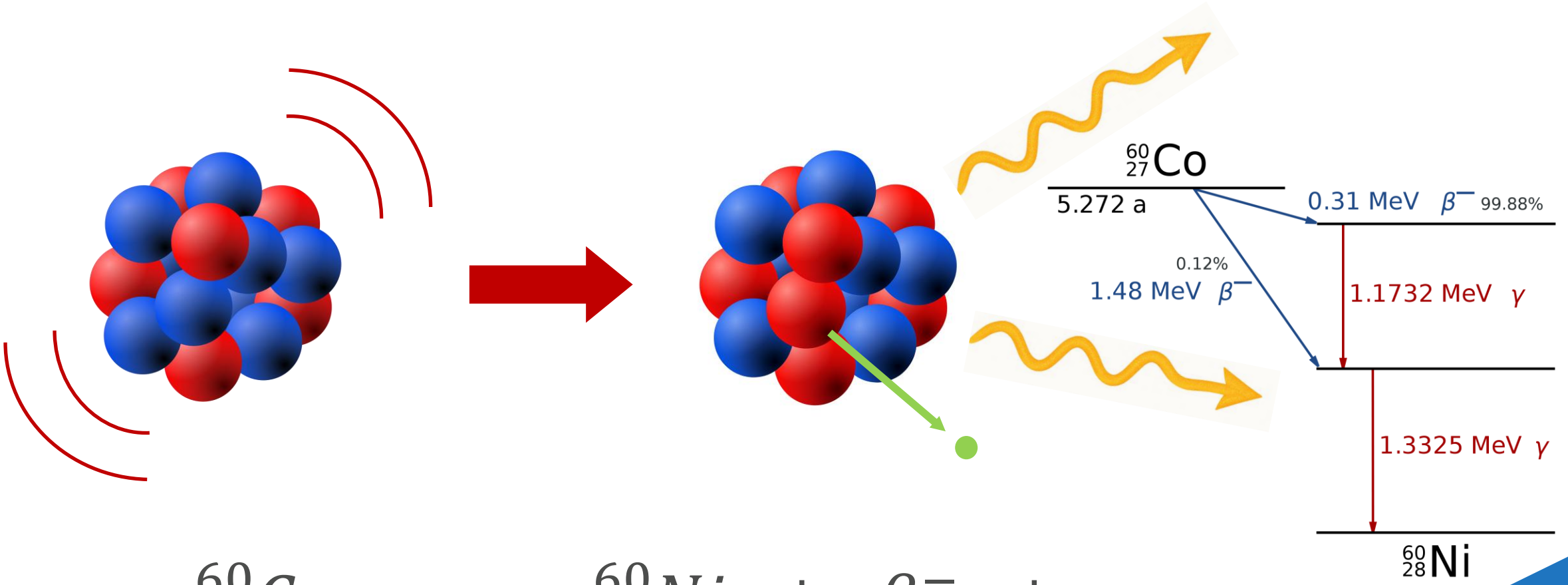
Science. Ingenuity. Sustainability.

# Electromagnetic spectrum



# What is gamma radiation?

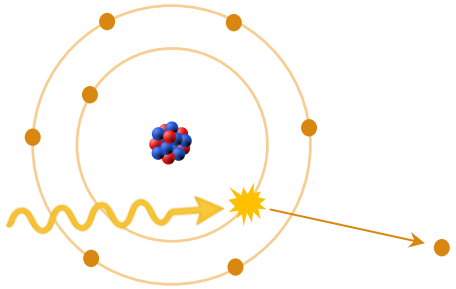



$$^{60}_{27}Co \rightarrow {}^{60}_{28}Ni + \beta^- + \gamma$$

# Interaction of radiation in matter

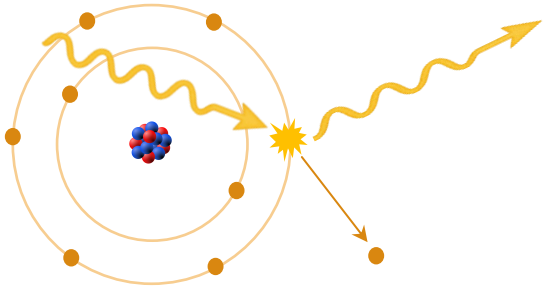
## Photoelectric effect

- Photon is **completely** absorbed by an electron, which is ejected from atom.



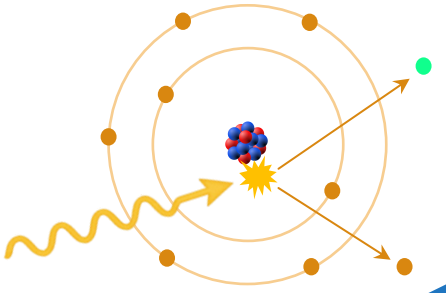
## Compton scattering

- Photon is **partly** absorbed by an electron, which is ejected from atom. Photon is scattered with less energy.



## Pair production

- Photon approaching nucleus is converted into electron-positron pair. Positron will quickly annihilate with an electron, producing two more photons at 511 keV.



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# Radiation damage

Single strand break

Double strand break

**Direct damage**

Electrons/photons cause direct damage to DNA

**Indirect damage**

Ionised species (e.g. hydroxyl radicals) react with DNA

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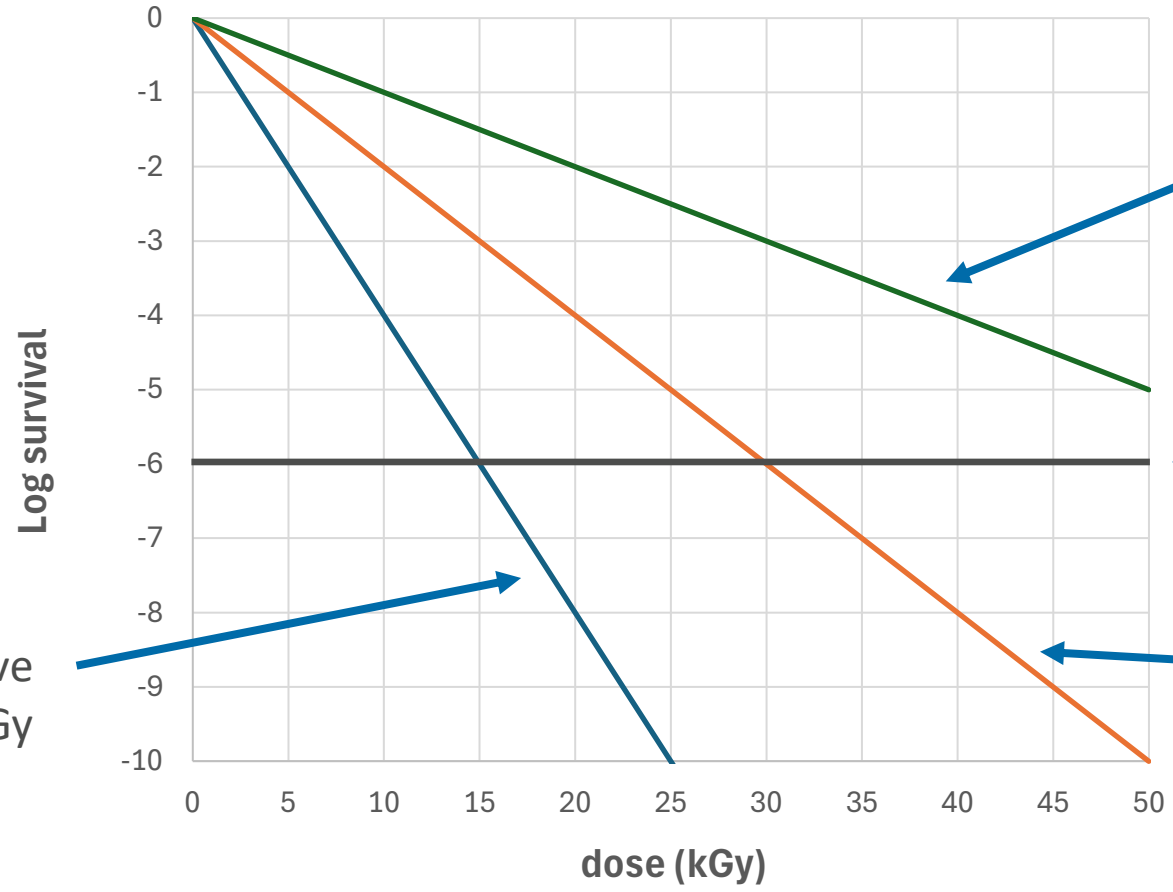
# Bioburden reduction

$$\log_{10}(N/N_o) = -D/D_{10}$$




Highly resistant
$D_{10}$ = 10 kGy

SAL $10^{-6}$

Moderate resistance
$D_{10}$ = 5 kGy

Radiation sensitive
$D_{10}$ = 2.5 kGy

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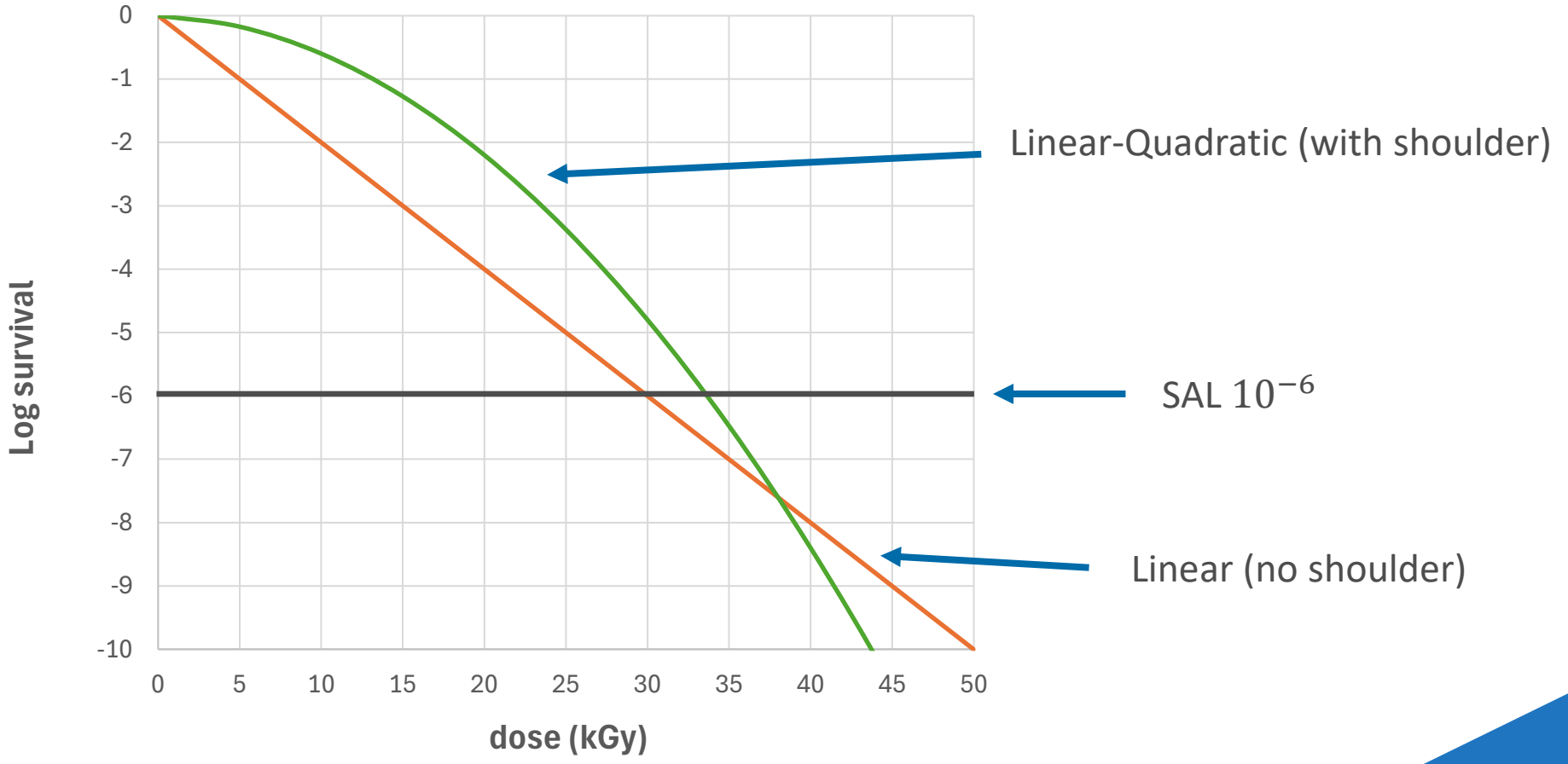
# Bioburden reduction

$$\log_{10}(N/N_o) = -\alpha D - \beta D^2$$

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# Radiation dosimetry

Absorbed dose is the amount of energy absorbed in a material, per unit mass of that material.

1 joule / kg = 1 gray (Gy)

Dosimeters measure a physical/chemical change upon exposure to ionising radiation.

- ✓ High sensitivity
- ✓ Linear with dose
- ✓ Accurate, precise, reproducible
- ✓ Long term stability
- ✓ Low toxicity
- ✓ Ease of manufacture and use

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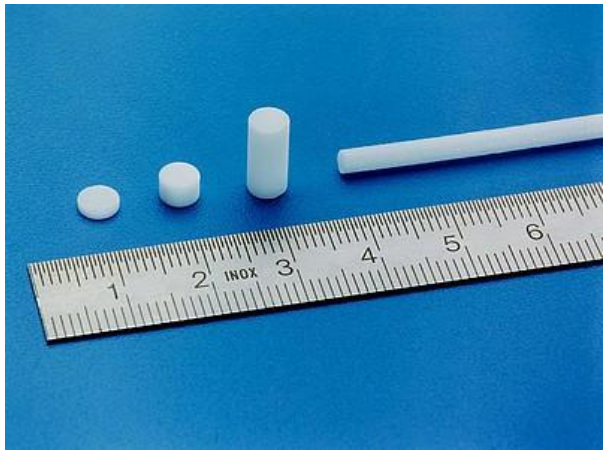
# Radiation dosimetry – Examples

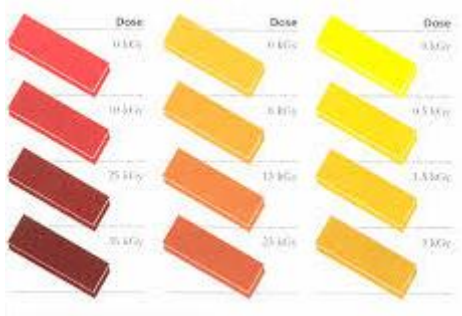
Ionisation chamber

Fricke


Ceric cerous



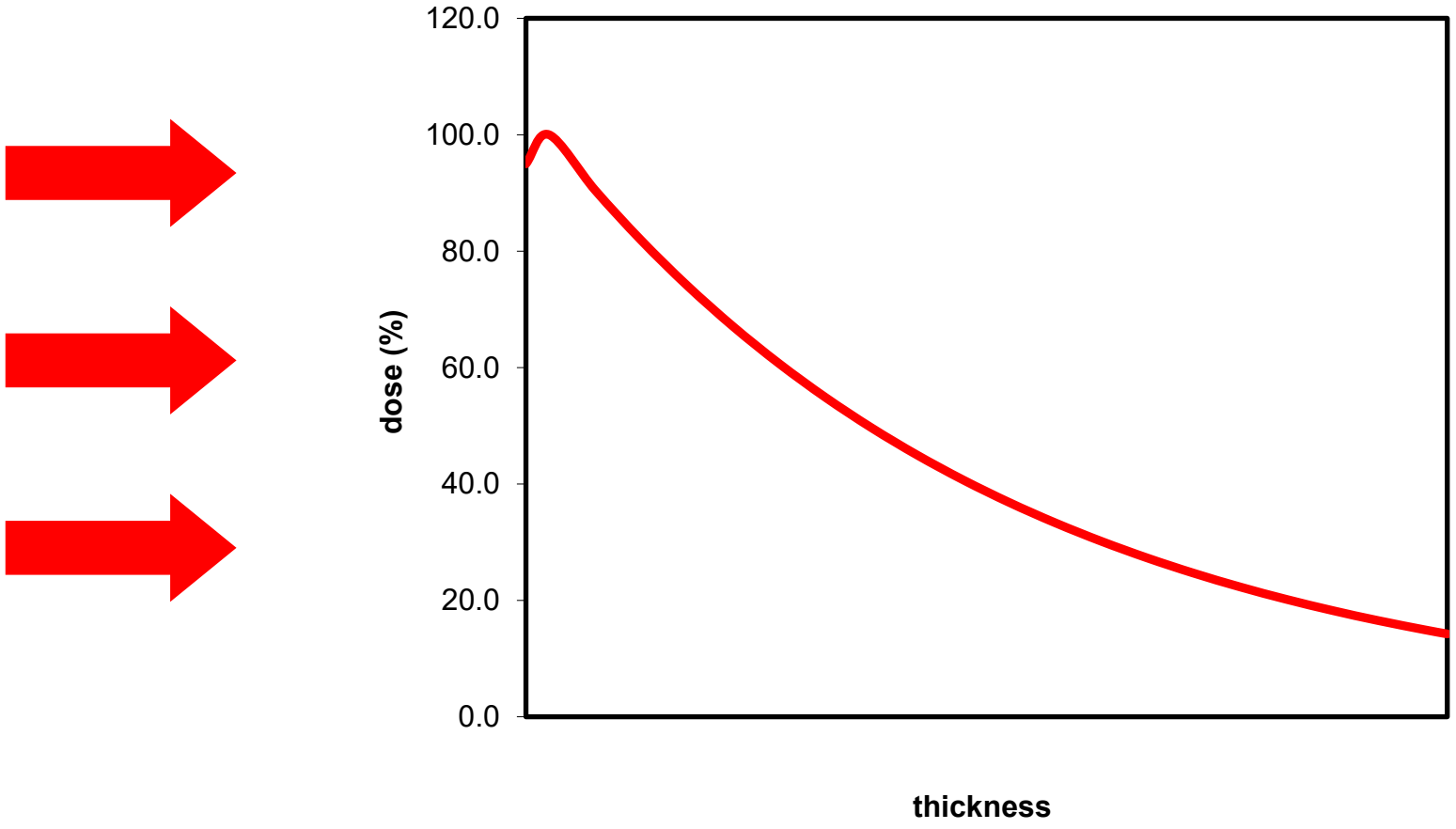

Alanine



Perspex

# Radiation attenuation

One-sided irradiation



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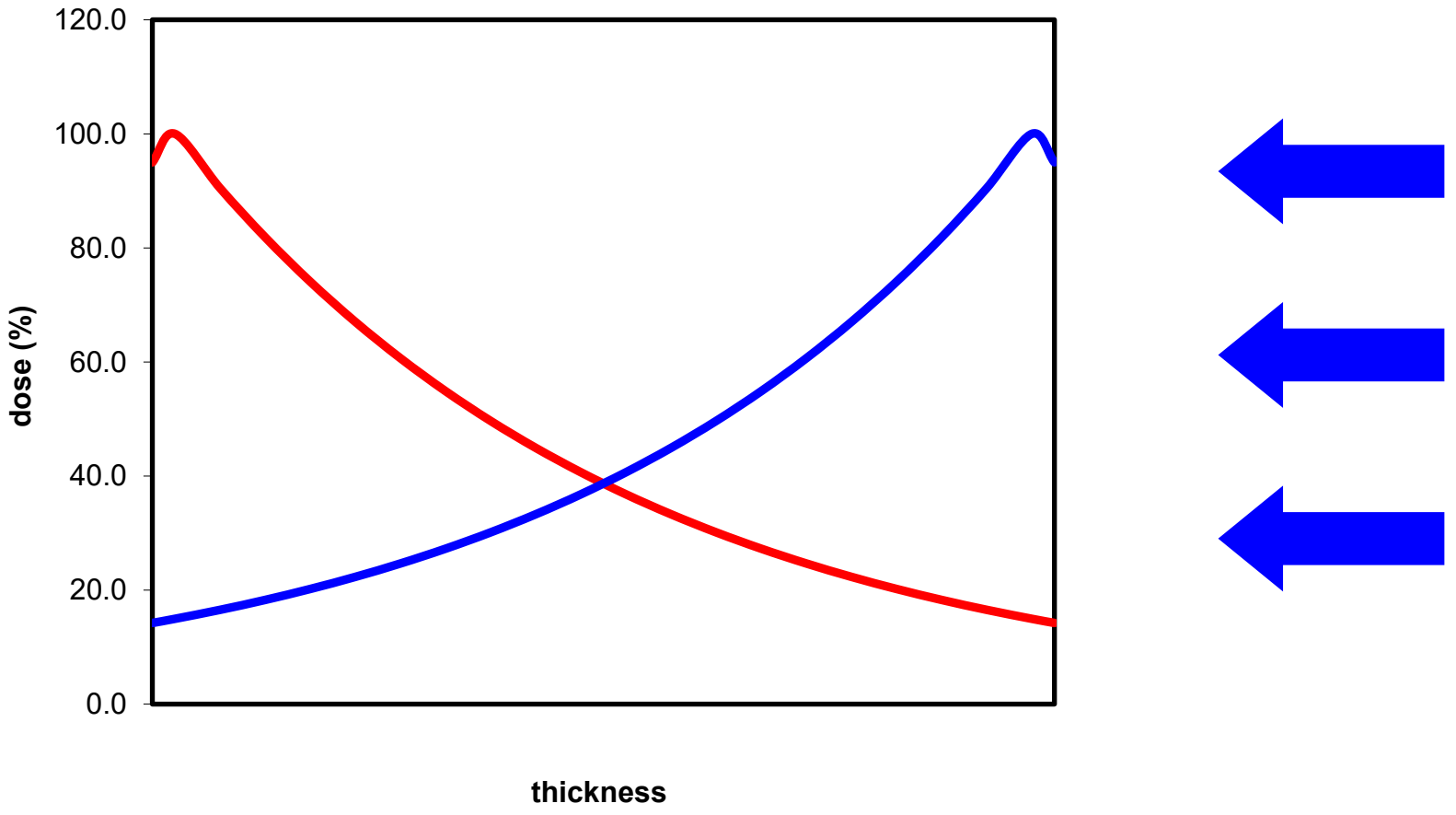
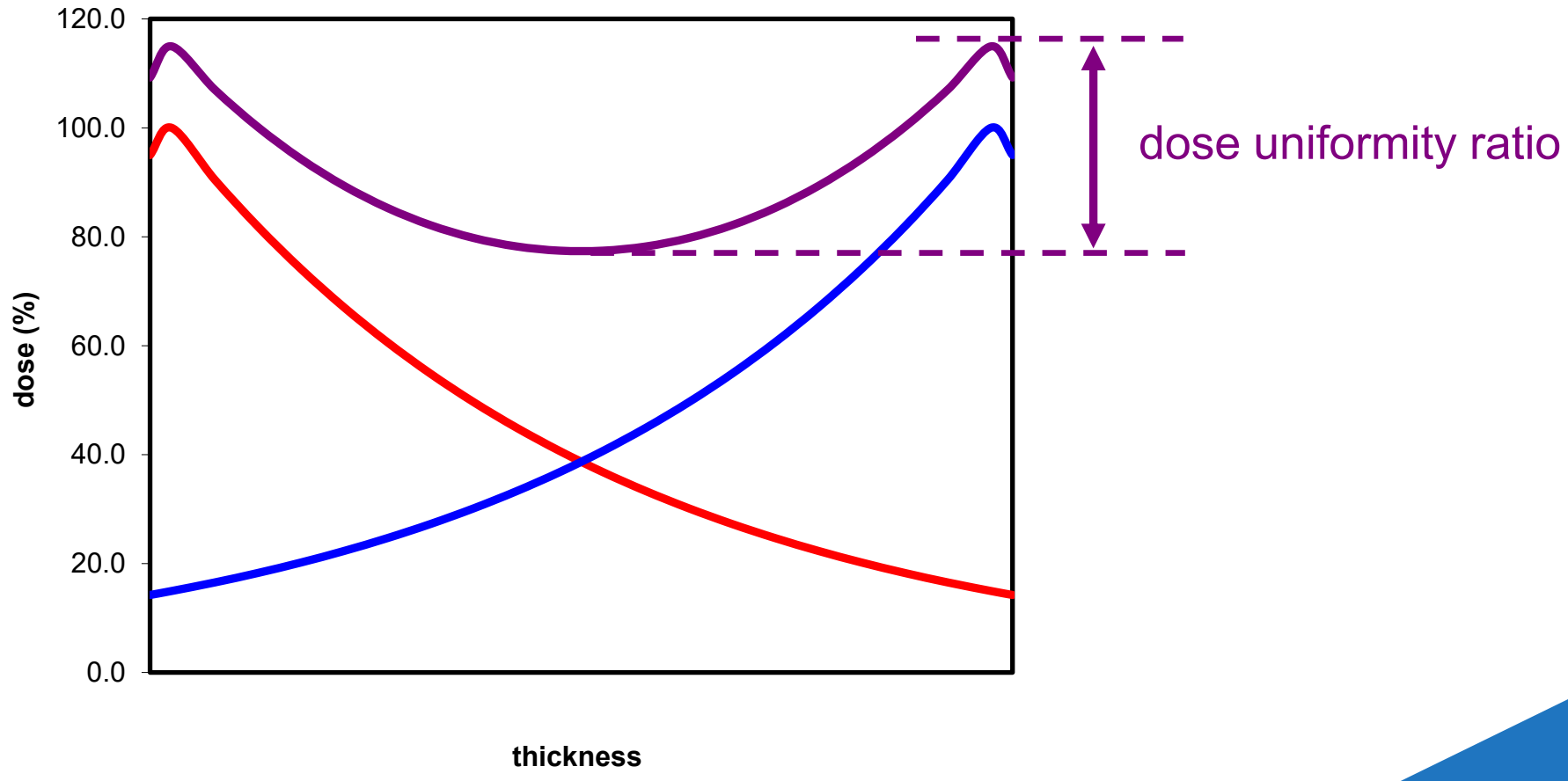
Two-sided irradiation



# Radiation attenuation

Summed doses



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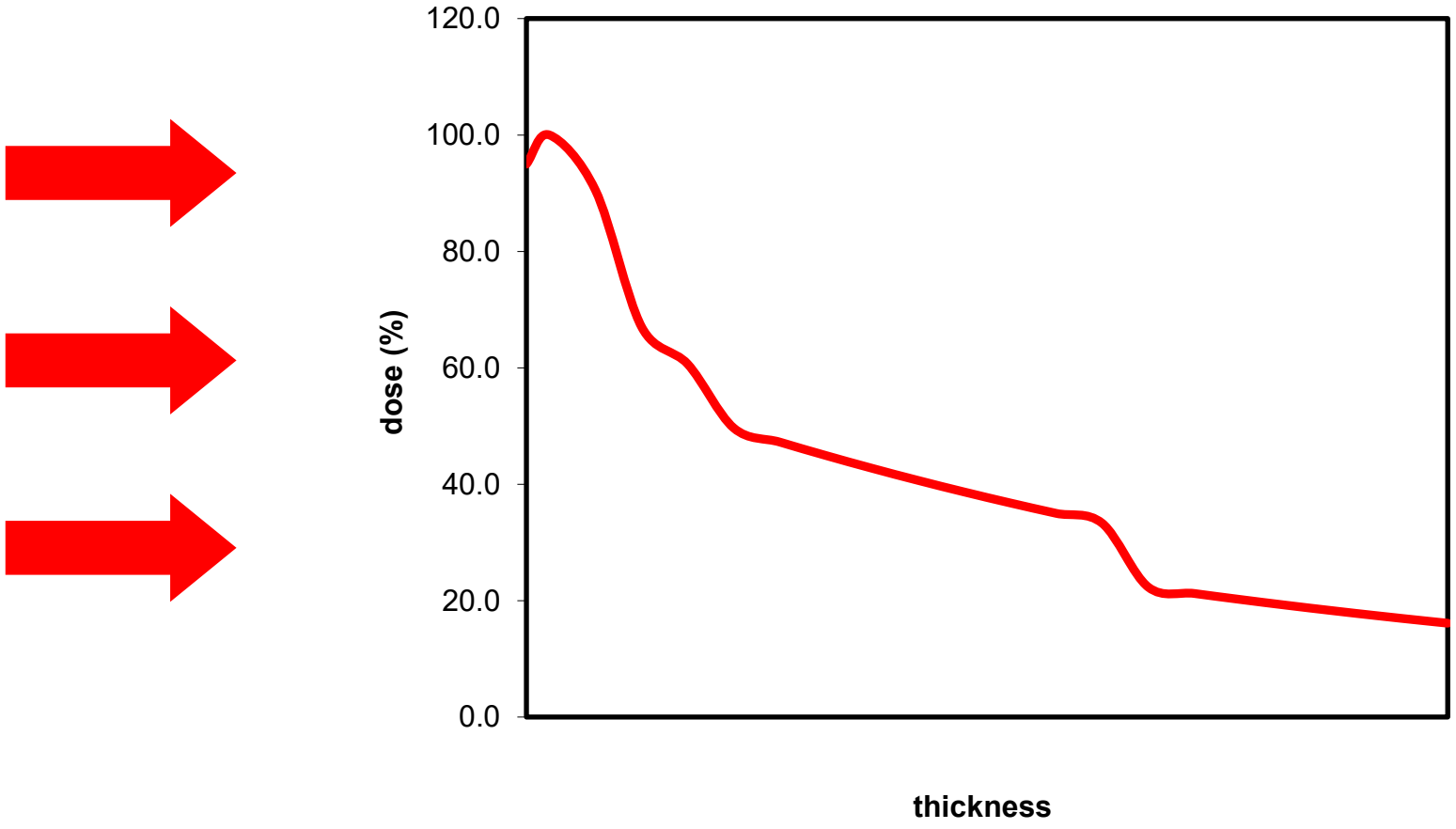

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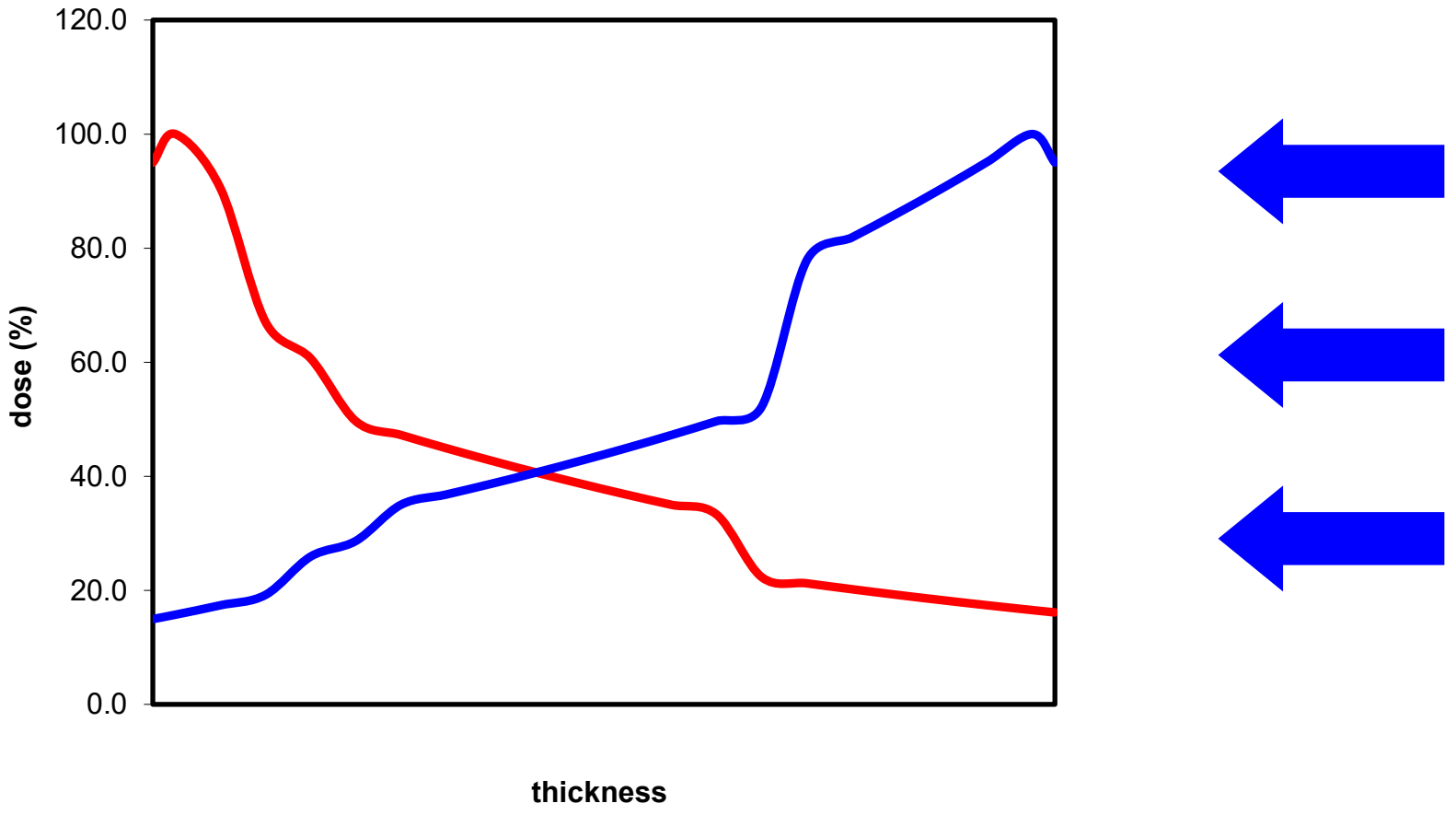
Two-sided irradiation



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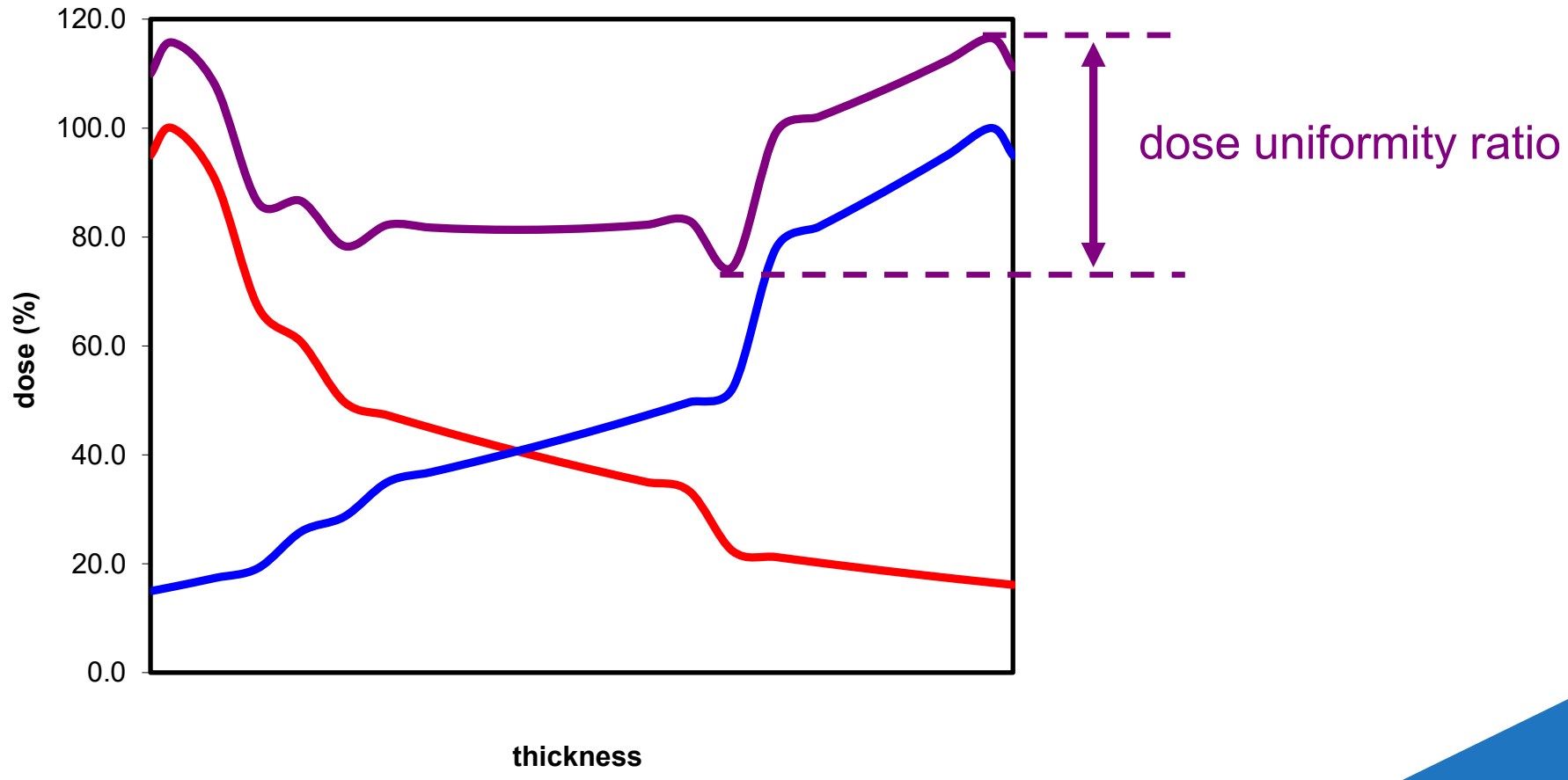
Summed doses



# Dose mapping

**Purpose**

To identify minimum and maximum dose locations within product load, and ensure all areas within product packaging receive the sterilising dose without exceeding maximum tolerable limits.

**When?**

Any new or significant change to source, product, packaging or loading configuration.

# Dose mapping

**Method**

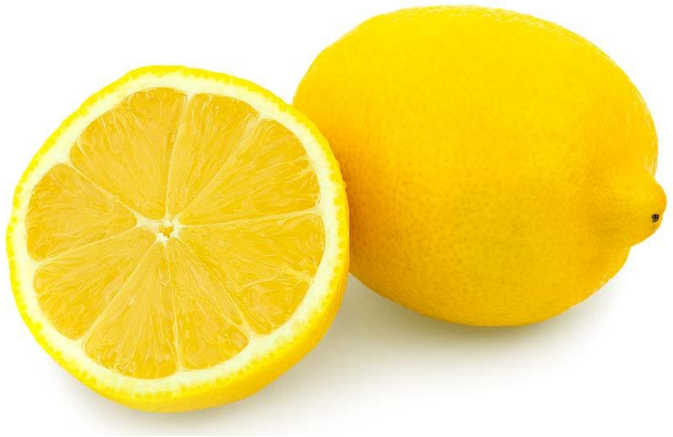
- Define product load: placement & orientation of product.
- Dosimeter placement: positions expected to receive min & max doses (based on measurements or models).
- Initial run: dosimeters in 3D array to find min & max doses. Include dosimeters in routine monitoring position.
- Repeat with dosimeters in min & max dose locations for reproducibility.
- Establish dose uniformity ratio (DUR) and factors that convert reading at monitoring position to min & max doses.
- Dosimeters at monitoring position for actual product.

# Plant Breeding

Irradiation creates random genetic changes

Near-seedless mandarins and lemons

Resistance to wheat stem rust



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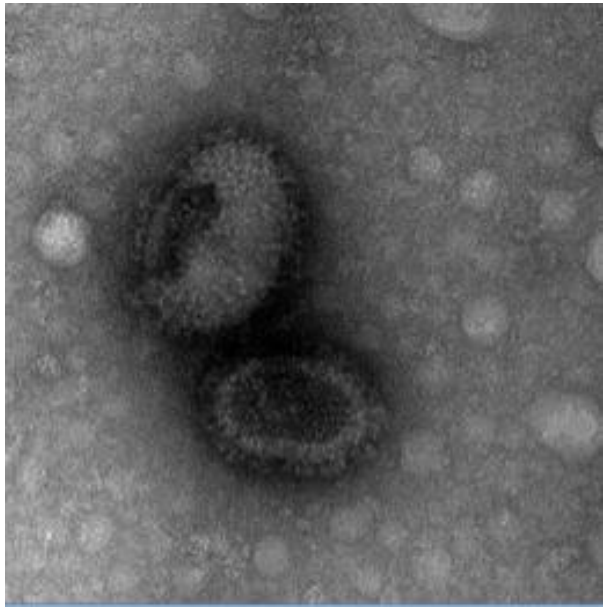
# Gemstones

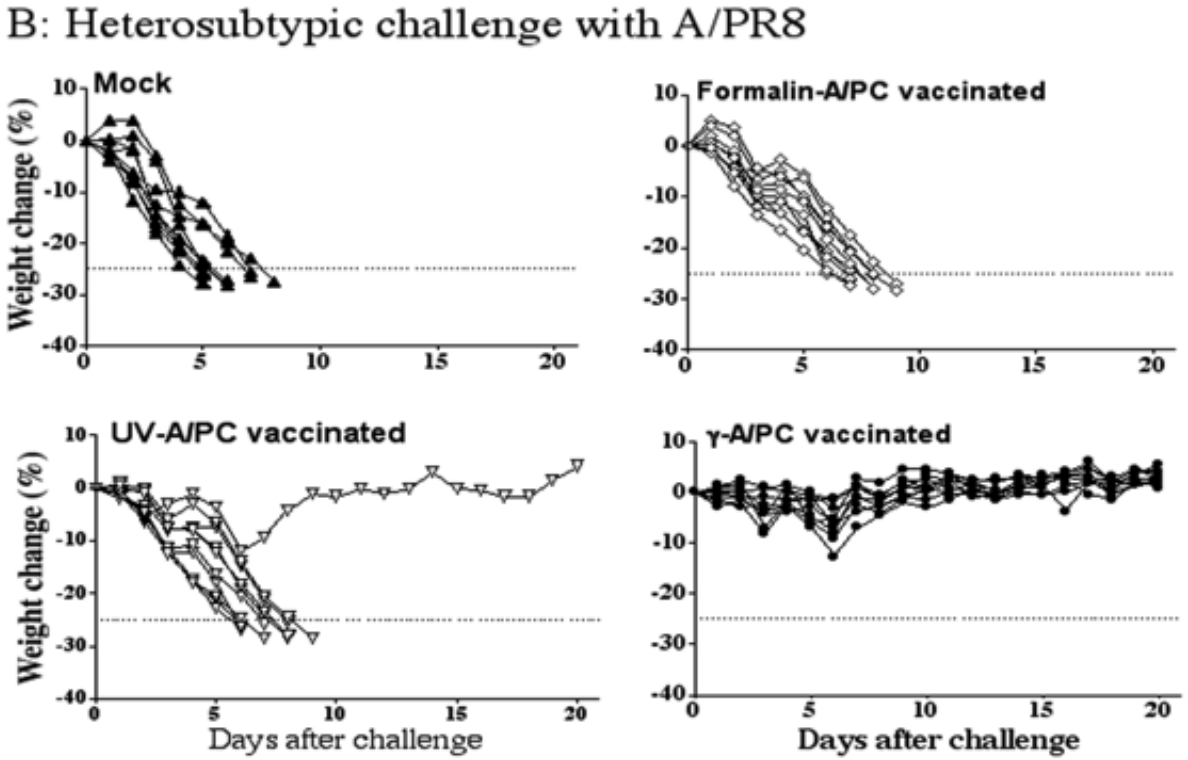
Irradiation of gemstones to induce and enhance colours

# Novel vaccines

Irradiation to inactivate pathogen to create a more effective (universal) vaccine.

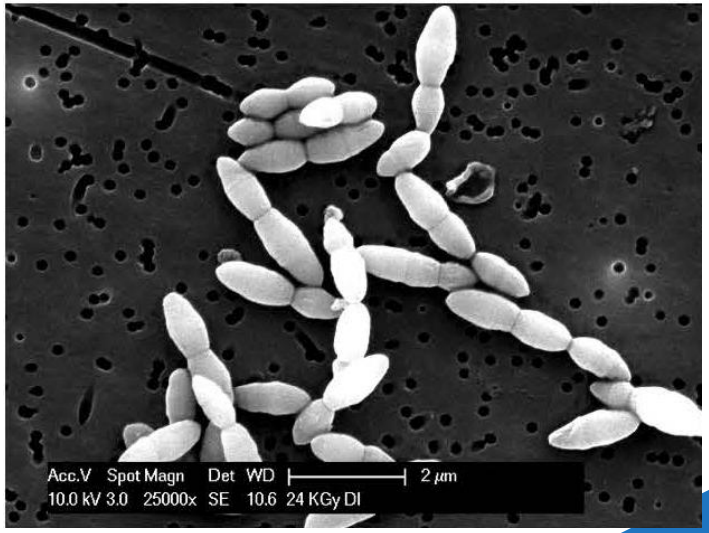


Gamma-irradiated H1N1
(courtesy University of Adelaide)




**Heterosubtypic challenge with H1N1 (A/PR8)**

| Vaccination | Protection |
|---|---|
| Formalin-H3N2 | No |
| UV-H3N2 | No |
| **γ-H3N2** | **Yes** |




Electron micrograph of Gamma-PN™
(courtesy University of Adelaide)

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# National Space Qualification Network

Collaboration with ANSTO, ANU, UoW and commercial partners

# Thank you

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