Outline

• Gamma radiation and how it works
• Dosimetry systems and traceability
• Dose mapping
• Applications
Cobalt-60 decay

$^{60}_{27}\text{Co}$

5.272 a

0.31 MeV $\beta^-$ 99.88%

0.12%

1.48 MeV $\beta^-$

1.1732 MeV $\gamma$

1.3325 MeV $\gamma$

$^{60}_{28}\text{Ni}$
Gamma Irradiators

Conveyor (pallet, carrier, tote)  Static (batch)
Gamma Irradiators

- Small scale Co-60 irradiator since 1970
- Very low (1 Gy) to High (> 50 kGy)
- R&D underpins industrial radiation processing
- Human tissue
- Medical products validation
Ionisation

ejected electron
Radiation Sterilisation

- Ionisation
- Chemical changes (free radicals)
- Biological damage
Radiation Sterilisation

Ionisation

Chemical changes (free radicals)

Measure of absorbed dose

Biological damage
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Dosimetry

- Fricke dosimeter – invented in 1920s
- Ferrous (Fe$^{2+}$) oxidised to Ferric (Fe$^{3+}$)
- Absorbs UV at 303 nm
- Reference dosimeter traceable to Australian standard
- 40 – 400 Gy (± 2.0%)
- Used to calibrate high dose rate radiation fields and in turn other dosimetry systems.
Dosimetry

- Ceric-Cerous dosimetry system – an Australian invention
- Ceric (Ce\(^{4+}\)) reduced to Cerous (Ce\(^{3+}\))
- Electro-chemical change
- Used world-wide
- Low Dose 1 – 12 kGy (± 3.0%)
- High Dose 10 – 35 kGy (± 3.5%)
Dosimetry

- Dyed perspex
- Visible colour change
- Used routinely world-wide
- Amber: 1-30 kGy
- Red: 5-50 kGy
<table>
<thead>
<tr>
<th>Traceability to Australian Standard</th>
<th>ARPANSA</th>
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<tbody>
<tr>
<td>Primary Standard</td>
<td>ANSTO</td>
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<td>Reference Dosimeter</td>
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<td>Routine Dosimeter</td>
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</table>
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Dose mapping

One-sided irradiation

![Graph showing dose mapping with depth and dose axes. The dose decreases exponentially as depth increases.]
Dose mapping

Two-sided irradiation

Dose (%) vs. Depth (cm)
Dose mapping

Total dose

![Graph showing dose mapping with depth (cm) on the x-axis and dose (%) on the y-axis. Three curves are present: one in red, one in blue, and one in purple. The red curve decreases from approximately 120% at 0 cm to 0% at 20 cm, the blue curve increases from 0% at 0 cm to approximately 120% at 20 cm, and the purple curve is a smooth curve that peaks at around 100% at 5 cm.]
Dose mapping

Total dose

dose (%)
depth (cm)
dose uniformity ratio

Total dose

Dose mapping

Product with inhomogeneous density

![Graph showing dose mapping with depth and dose (%). The graph highlights a product area with a specified dose uniformity ratio.]
Dose mapping

Dose uniformity of smaller product

- Product
- Dose uniformity ratio

Graph showing dose mapping with depth and dose (%).
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QLD fruit fly

- Sterilisation of QLD fruit fly is used to protect fruit growing regions in VIC-NSW-SA
- Sterile Insect Technique (SIT) used for different pests worldwide
Food Irradiation

- Irradiation of tropical fruits helps to prevent spread of QLD fruit fly overseas
- Improves export market access for growers
- An alternative to pesticide treatments (no chemical residues)
Food Irradiation

- FSANZ approved irradiation of tomatoes as alternative to banned pesticides dimethoate and fenthion.

**THE AUSTRALIAN**

Tomatoes to be zapped with radiation to destroy insects after new food standards declared

KAREN COLLIER HERALD SUN APRIL 17, 2013 12:01AM

Source: The Sunday Mail (Qld)

TOMATOES zapped with radiation could be heading towards your lunchbox or dinner table.

Food Standards Australia New Zealand has declared the treatment -- to destroy insects and bacteria, but which has been linked to pet deaths -- is safe for fresh tomatoes and capsicums.

FSANZ spokeswoman Lorraine Belanger said irradiated food passed through a radiation field generated by high-energy electron beams, X-rays or gamma rays.

Irradiated food must be labelled and notices placed at sales areas or on menus.

Queensland’s Department of Agriculture, Fisheries and Forestry wants the option of an alternative fruit fly control after restrictions were imposed on dimethoate and fenthion, two common chemical insecticides.
American foulbrood

• Irradiation of beehives to eliminate American foulbrood from affected hives
Water contamination

- Inactivation of cryptosporidium and giardia parasites provides a reference standard for water contamination testing.
Beach worms

• Quarantine irradiation of frozen beach worms from Indonesia for the supply of fishing baits

Human tissue

- Sterilisation of human bone and soft tissue for transplant and grafting.

Images courtesy of Perth Bone and Tissue Bank
Healthcare

- Disposable medical supplies and implant devices to ISO11137 for verification dose experiments
Healthcare technology

• RFID devices used in a variety of applications including the tracking of healthcare consumables.

• Required to demonstrate that the devices can survive high doses used in radiation sterilisation

Image courtesy of Bluechip P/L
Immunology

- Irradiation to inactivate influenza viruses to create more effective vaccines
- ANU research leading to mass production of vaccines
- Expansion of technique to other viruses
Biotechnology

- Irradiation to create advanced materials in biotechnology;
  - hydrogels, micro- and nano-spheres for drug delivery devices
  - raw materials
  - ointments
Summary

- Irradiation technology is a well understood process for sterilisation
- Relies on dosimetry systems traceable to primary standards
- Dose mapping is required to determine the final dose to product
- Wide range of applications