Can we deliver a sustainable supply of medical radioisotopes by harvesting them from existing material?

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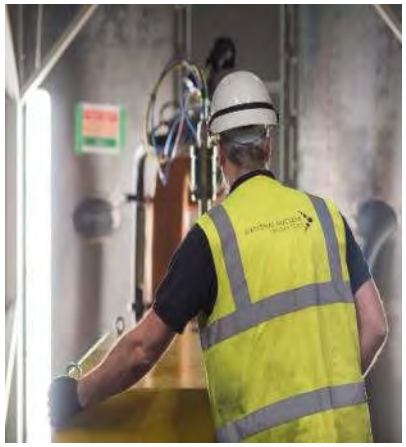
NATIONAL NUCLEAR LABORATORY

INTRODUCTION

- NNL is the UK's national nuclear laboratory which operates on an autonomous commercial basis
- NNL is owned by the UK government and has three roles given to it by the government
- NNL operates world leading facilities doing world class science

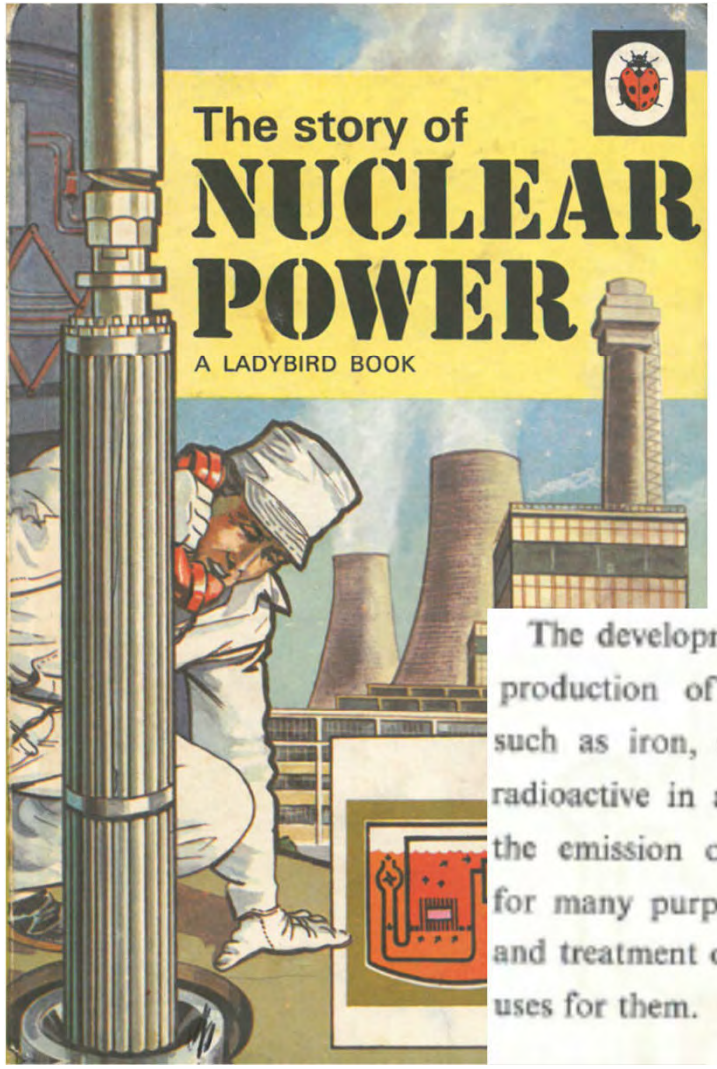
SUPPORT FOR ALL NUCLEAR PROGRAMMES

- Continued operation of existing reactors and fuel cycle facilities (fuel fabrication, reprocessing)
- Legacy waste management / decommissioning
- New nuclear build
- Geological disposal
- Plutonium stockpile disposition
- Naval propulsion support
- Advanced reactor and fuel cycles
- Space energy systems
- Security, non-proliferation and safeguards



FACILITIES

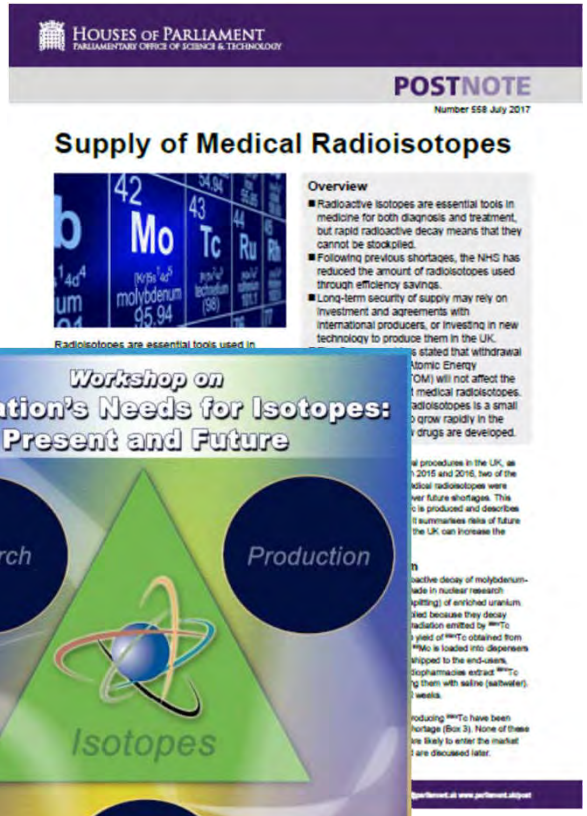
- Non active and active labs
- High active alpha labs
- Beta and gamma hot cells
- Plutonium and MOX facilities
- Graphite labs
- Full scale test facilities

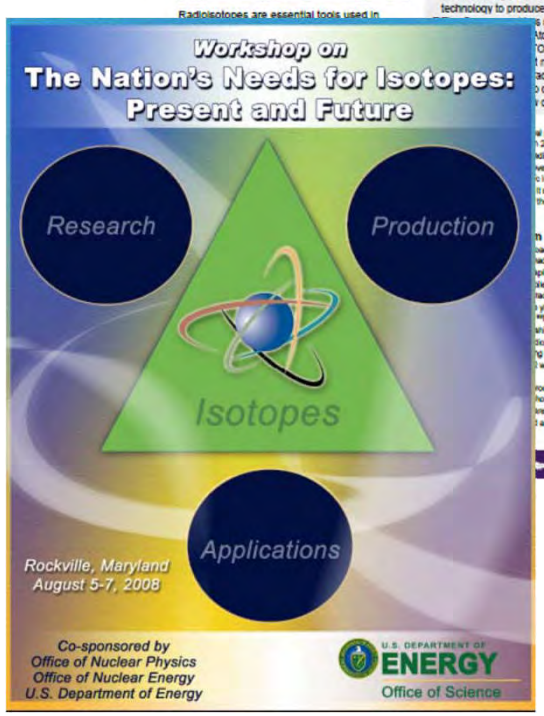


The development of this new industry included the production of *radioisotopes*. These are substances such as iron, cobalt and iodine which can be made radioactive in a nuclear reactor. Their radioactivity, the emission of various sorts of rays, can be used for many purposes. Hospitals use them for diagnosis and treatment of diseases, and industry, too, has many uses for them.

NEED FOR ISOTOPES

- Demand for radioisotopes is increasing across the world, especially for medical use
- Increasing demand for current radioisotopes, and new demand for new radioisotopes
- Diagnostics is still the dominant area, with therapy needs increasing as new treatments are developed
- Traditionally manufactured in reactors, many have now closed across the globe and increasingly difficult to get new ones built
- Cyclotron manufacture seen as possible solution
- Harvesting from existing material also an option





USES OF RADIOISOTOPES - MEDICAL

- Specialist field where specific short lived radioisotopes are produced in dedicated facilities
- New procedures may well require new radioisotopes to become available
- Medical grade requirement
- Technetium-99m is the principal radioisotope currently used in medical diagnostics worldwide, ~85% of the global radiopharmaceutical market

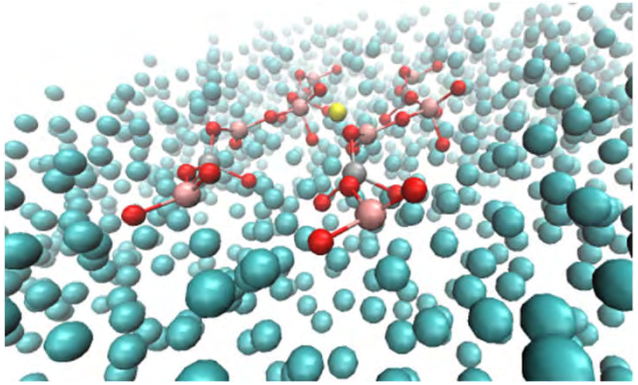


Image courtesy of IOP

TAT – TARGETED ALPHA THERAPY

- The “Trojan Horse” of medical treatment using radioisotopes
  - an α-particle emitting radionuclide can be chemically bound to a targeting biomolecule which carries the combined radiopharmaceutical to a specific treatment point
- It has the potential to provide highly targeted treatment, especially to microscopic tumour cells.
- The short path length and the intense ionization path generated by α-emitters offer advantages over β-emitters such as Yttrium-90
- Best suited for treatment and management of minimal disease such as micrometastases or residual tumour after surgical debulking

SITE CLOSURE

- UK were world leading on isotope manufacture
  - In the 1950s, Harwell's division of isotopes provided most of the radioisotopes consumed in Western Europe
  - In the 1960s, Amersham was one of most important players in the increasingly global market of radioisotopes.
- Ability to make new material lost
  - Over 30 UK research reactors closed with none still operating
  - The UK at present has limited capacity restricted to a small number of cyclotrons that manufacture mainly Florine-18 for PET
- Legacy material in storage and needs management

Image Harwell Parish Council, NDA

NUCLEAR LEGACY

- 60+ year legacy
- R&D, operations and plant commissioning programmes
- Significant R&D programmes ongoing within National Laboratories, universities and industry
- Radioactive material exists in almost every conceivable state

- Challenge – Smarter, Cheaper, Quicker
  and of course, safer and protecting the environment

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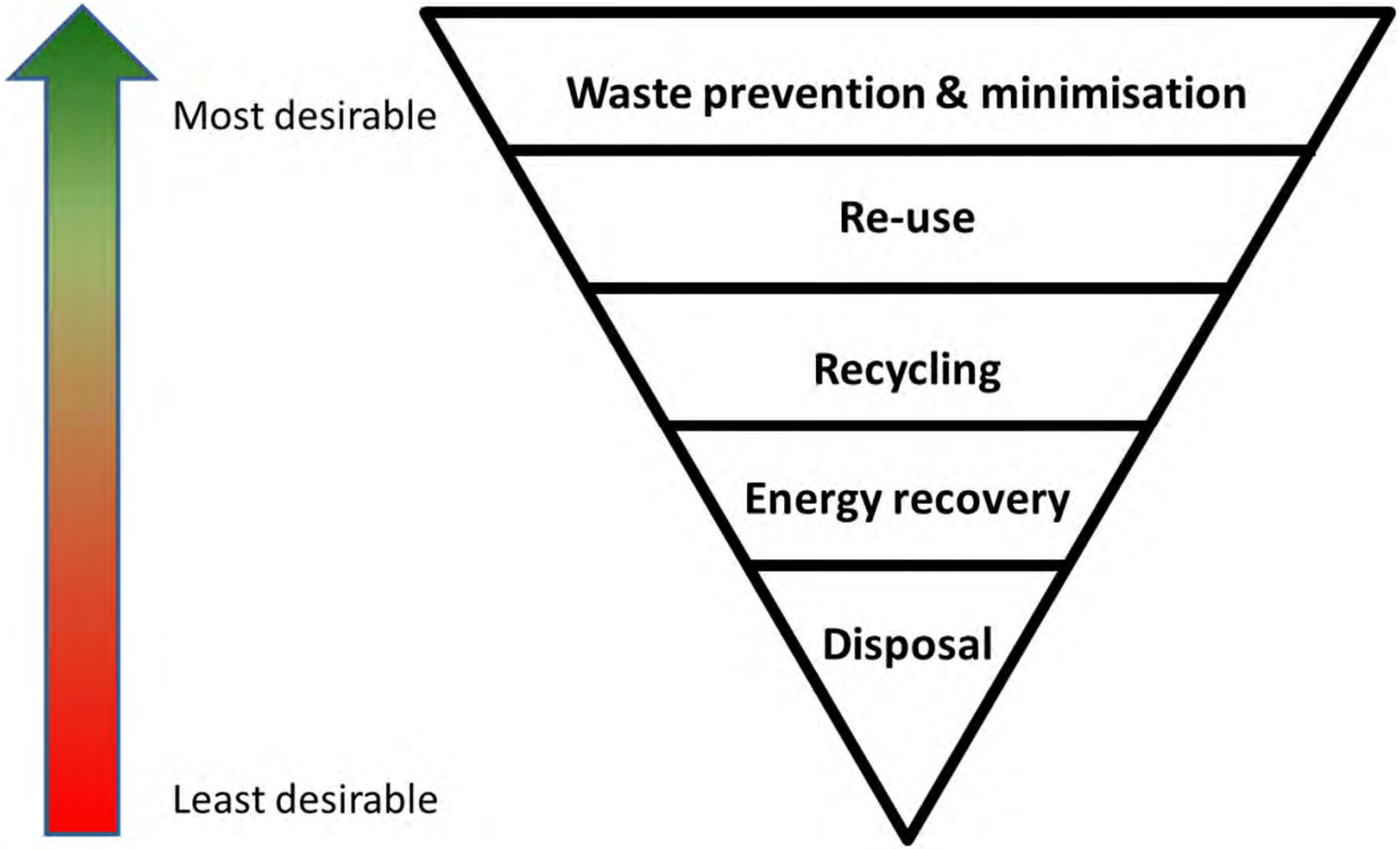
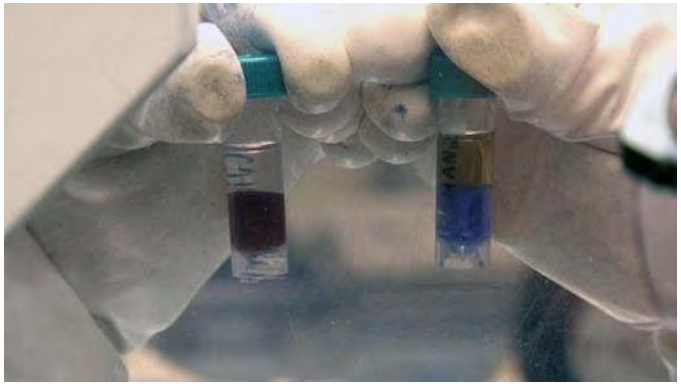
WASTE HIERARCHY



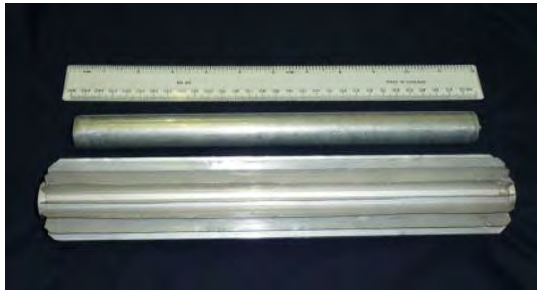
INDUSTRY ALIGNMENT

- Structure of industry focused on safe disposal
- The owners of the radioisotopes may not be aware of the need from potential users for specific radioisotopes
- Potential users or suppliers may not be aware of legacy material that could be being stored destined for eventual disposal
- “Value” not always visible to the owner “*Where there's muck there's brass*”



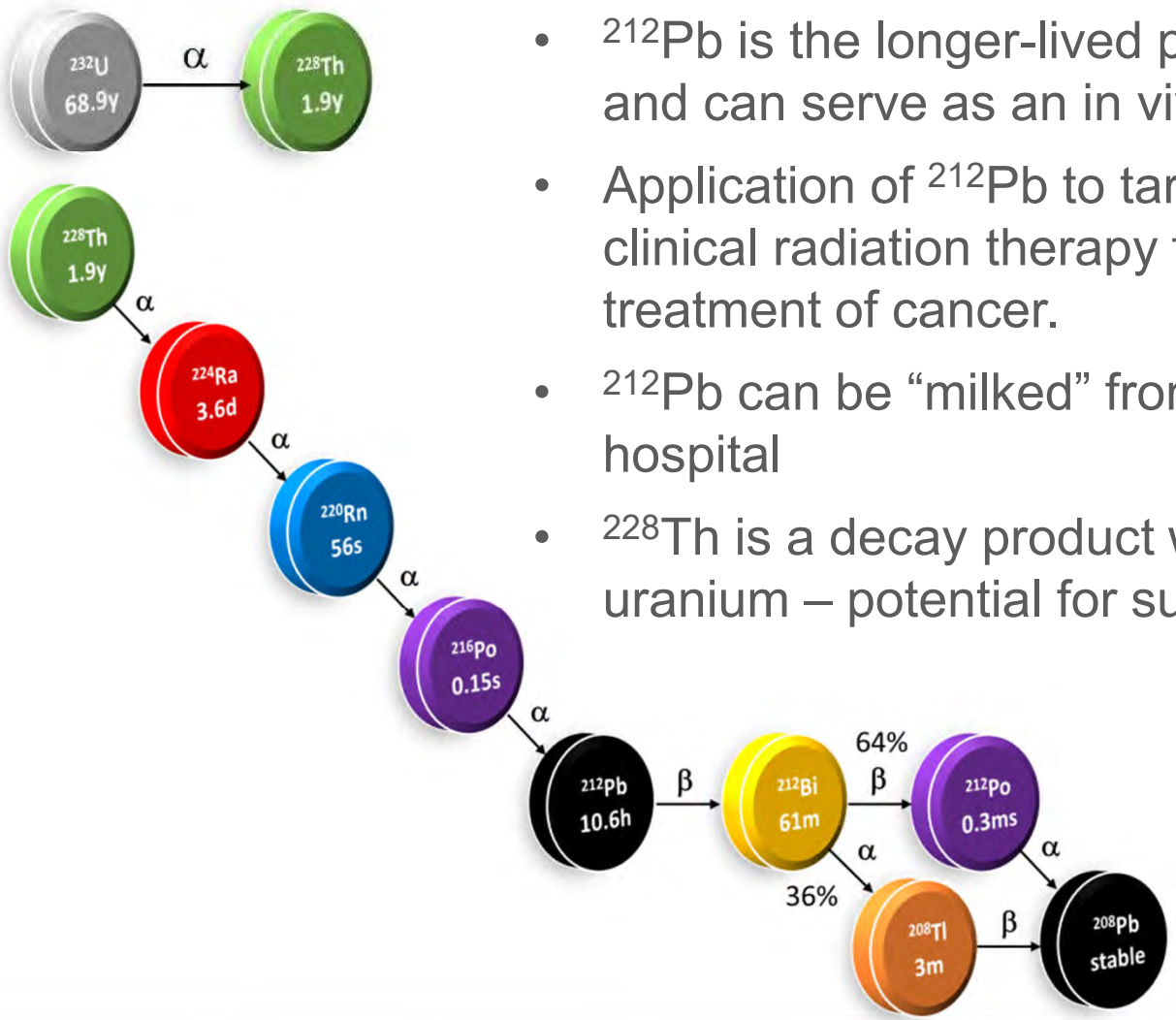
LEGACY MATERIAL

- There is a plethora of unirradiated and irradiated materials in store across the UK including:
  - Depleted, reprocessed and natural Uranium
  - Enriched Uranium
  - Mixed U/Pu oxides
  - Thorium as metal and oxides
  - Redundant sealed sources
  - Unprocessed targets
  - Research radioisotopes



Before we throw these all away, is there value in them?

HARVESTING – LEAD 212 EXAMPLE



- ^{212}Pb is the longer-lived parent radionuclide of ^{212}Bi and can serve as an in vivo generator of ^{212}Bi.
- Application of ^{212}Pb to target pre-clinical and clinical radiation therapy for the management and treatment of cancer.
- ^{212}Pb can be “milked” from a ^{228}Th generator at the hospital
- ^{228}Th is a decay product within separated civil uranium – potential for sustainable supply

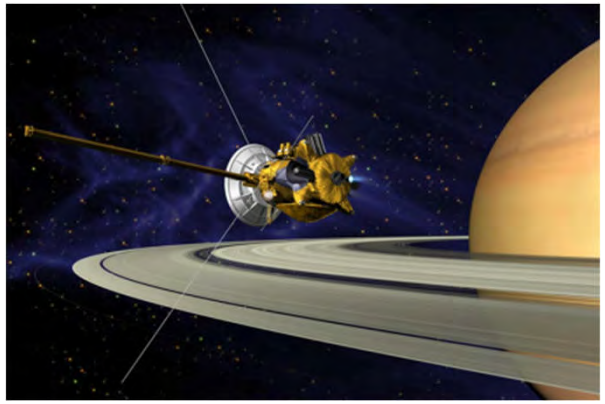
CHANGING THE MARKET

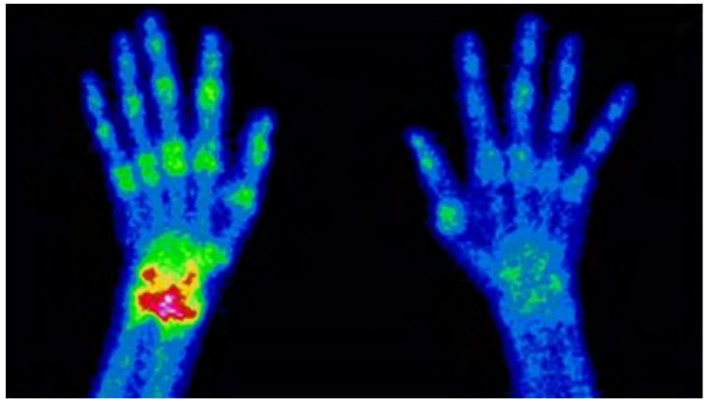
- Structure of industry is not focused on reuse
- The owners of the radioisotopes may not be aware of the need from potential users for specific radioisotopes
- Potential users, researchers or suppliers may not be aware of legacy material that could be being stored destined for eventual disposal
- A more structured engagement could yield significant value

- Other possible opportunities
- ^{226}Ra/Be redundant sources could be used for targets to manufacture Actinium-227
- Yttrium-90 extractable from waste containing high levels of Strontium-90
- Actinium-225 extraction from Uranium

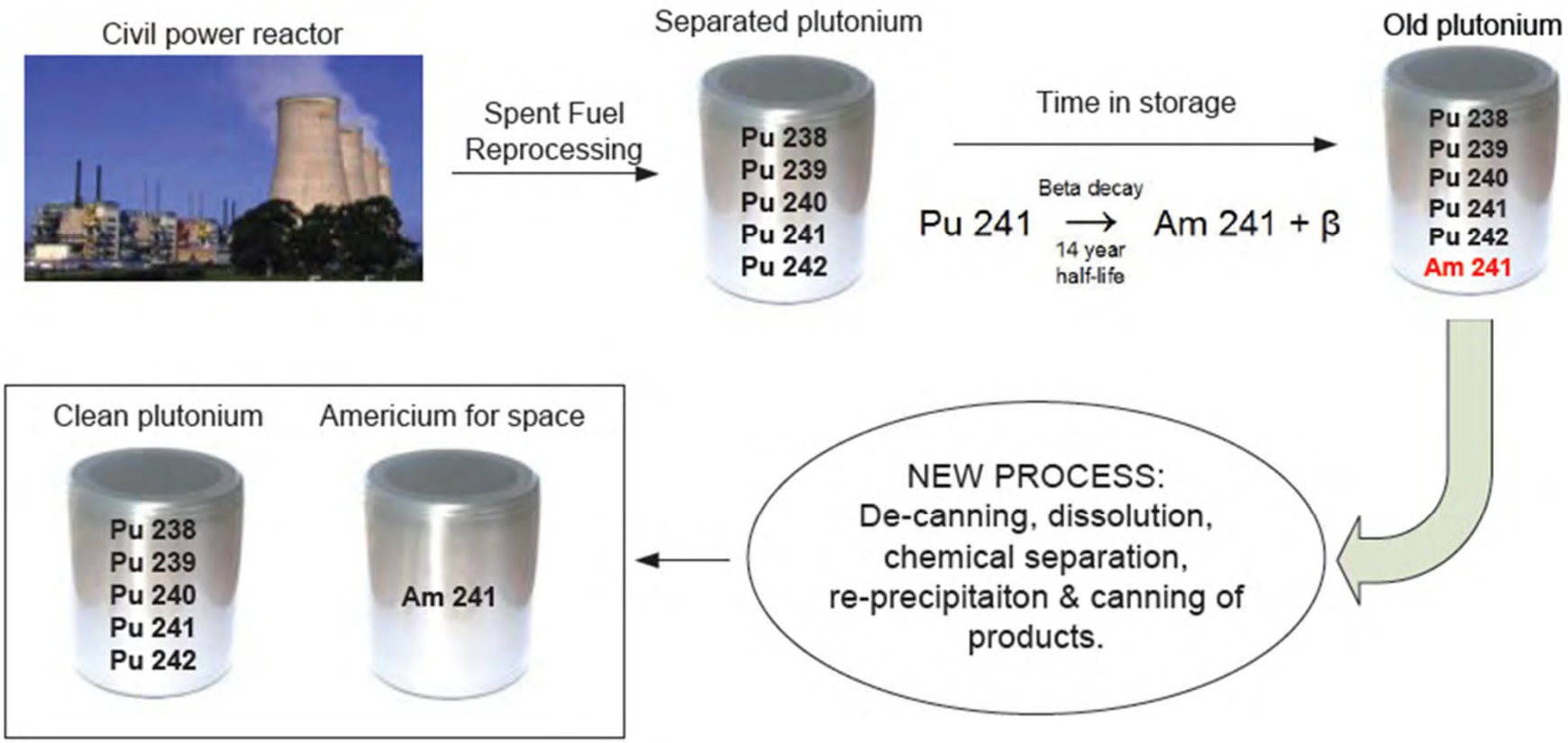
NNL ACTIVITIES

- Since 2009, ESA contract developing Americium-241 extracted from plutonium stocks for space power
- Socialising the opportunity for isotope harvesting
- Identifying legacy material that might hold value
- Discussion with a number of medical companies to support TAT
    - Current opportunities identified
    - Others on the horizon
    - Investment could provide others



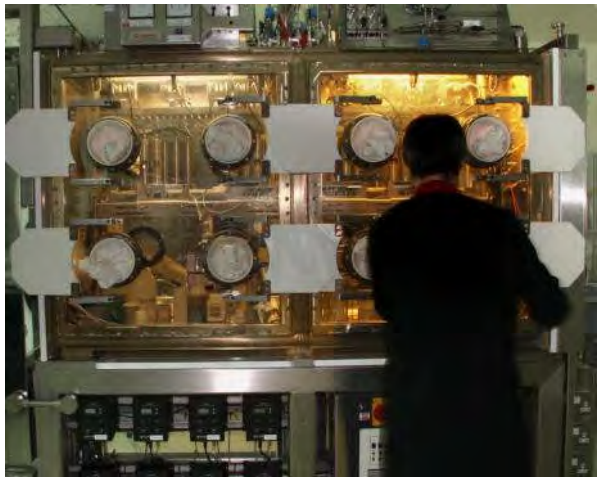


RADIOISOTOPES FOR SPACE POWER EXAMPLE



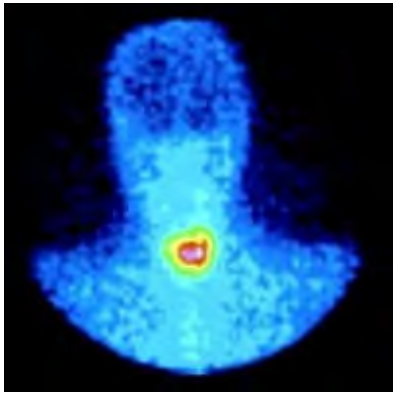
NNL CAPABILITIES

- High inventory facilities
- Alpha containment
- Heavily shielded hot cells
- Facilities and skills able to process and recycle material
- Access to legacy material
- Capacity to expand e.g. Cyclotron



SUMMARY AND WAY FORWARD

- UK was a leader in the supply of radioisotope
- Legacy material provides an opportunity for new supply routes
- To harness the opportunity we need to:
  - Engage with users to consider need for medical isotopes and determine demand
  - Engage with owners of the possible sources of material
  - Determine process requirements/viability
  - Consider teaming opportunities



Thank you for listening

Any questions?

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