Particle Accelerators

The Medical Prospective

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Contents

• Particle applications and some challenges
• Diagnostics and therapeutic drivers
• Nuclear Medicine and accelerators
• Options for moving from Reactor to Cyclotron generated diagnostic products
Challenges

- Need to reduce dose in both Diagnostic and Therapeutic applications
- Advancing ranges of treatments
- Optimising access
- Instability in supply chain
- Working at the leading edge of developments
Nuclear Medicine

• Open source radiation
• Uses an agent for:
  – Transportation
  – Visualisation
  – Quantification
• Single Photon with CT or Positron Emission Tomography - PET CT
Main uses of Diagnostic Isotopes

• SPECT
  – Visualize heart blood flow and function
  – Scan lungs for respiratory and blood flow problems
  – Evaluate for metastatic bone disease
  – Investigate abnormalities in the brain, such as seizures, memory loss and abnormalities in blood flow
  – Locate the presence of infection
  – Measure thyroid function to detect an overactive or underactive thyroid

• PET CT
  – Whole body Tumour localisation and spread
  – Functional imaging with dynamic molecular take up
  – Quantification
Clinical Management questions for imaging

• When is imaging required?
• Intra organ detection and localisation (to direct biopsies and RT boost)
• Prediction of tumour behaviour
• Nodal and distant metastatic staging
• Therapy for optimum response - Targeting
SPECT

take up and function capability
PET CT combination capability
The Aging Fleet

NATIONAL RESEARCH UNIVERSAL
Chalk River, Canada
Built 1957

40%

HIGH FLUX REACTOR
Petten, Netherlands
Built 1961

30%

OSIRIS
Saclay, France
Built 1964

9%

BELGIAN REACTOR-2
Mal. Belgium
Built 1961

3%

SAFARI-1
Pelfinbaba, South Africa
Built 1965

10%

How technetium-99m is produced

URANIUM-235
Irradiated with neutrons for several days in reactor

NUCLEAR FISSION

MOLYBDENUM-99
Purified, placed in lead-lined "generator" and transported to hospitals

TECHNETIUM-99m
With a short (6 hour) half-life this gamma ray emitter is used for imaging organs

BETA DECAY
Cyclotron production of $^{99m}\text{Tc}$
Yield Comparison: Energy, Current Considerations

Production Yields

- 16 MeV (130 uA)
- 16 MeV (200 uA)
- 19 MeV (300 uA)
- 19 MeV (500 uA) theor.
- 24 MeV (500 uA) theor.

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Side Reactions: $^{94-97}\text{Mo}(p,n)$

Irradiation Energy

Cyclotron and Radiochemistry Developments

• Production cyclotron considerations:
  – Containment
  – Supply chain geography
  – Multiple targets for combined run production

• Radiochemistry issues:
  – Targeted tracers and new indications
  – Reduced preparation Chelators
  – Extended range of Pharmacy ‘Kits’
Summary

• Nuclear Medicine is rapidly developing
• Reactor and Cyclotron created isotopes will be needed
• Getting closer to targeted diagnostic agents with precision therapeutic agents
• Half live determines the PET configuration
• Developments are High energy / Integrated shielding /Multiple targets for Isotopes production
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