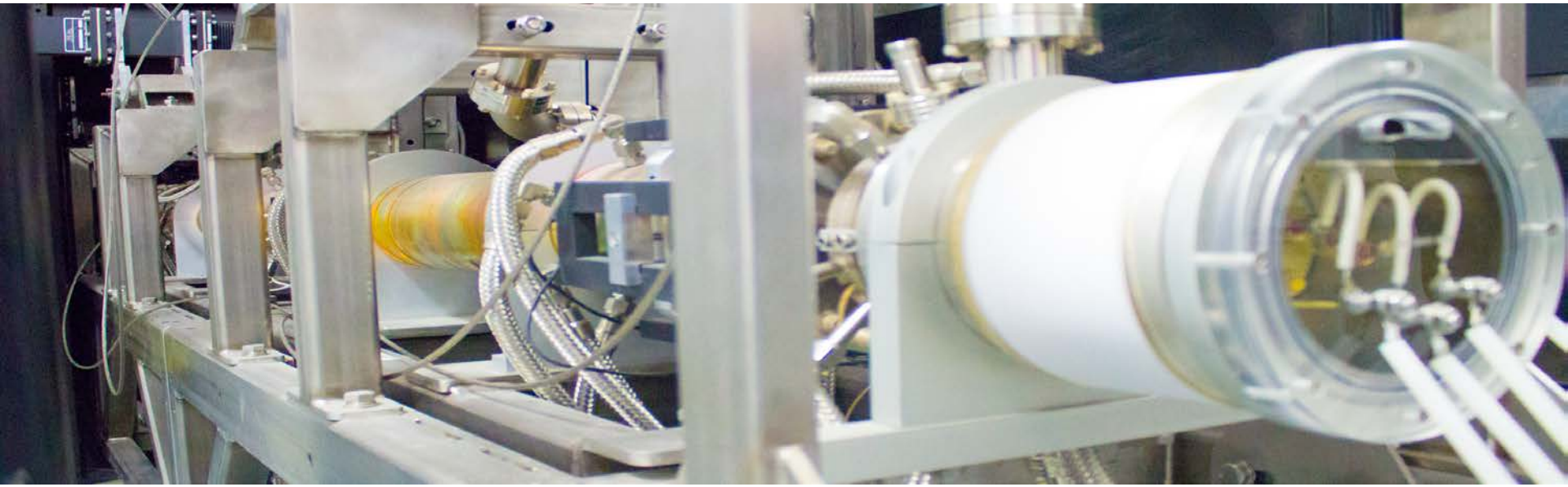
CANADIAN ISOTOPE INNOVATIONS

A New Paradigm for Mo-99/Tc-99m Supply

Mark de Jong
Chief Technology Officer

2017 Mo-99 Topical Meeting – Montreal – 2017 September 10-13

Canadian Isotope Innovations (CII)

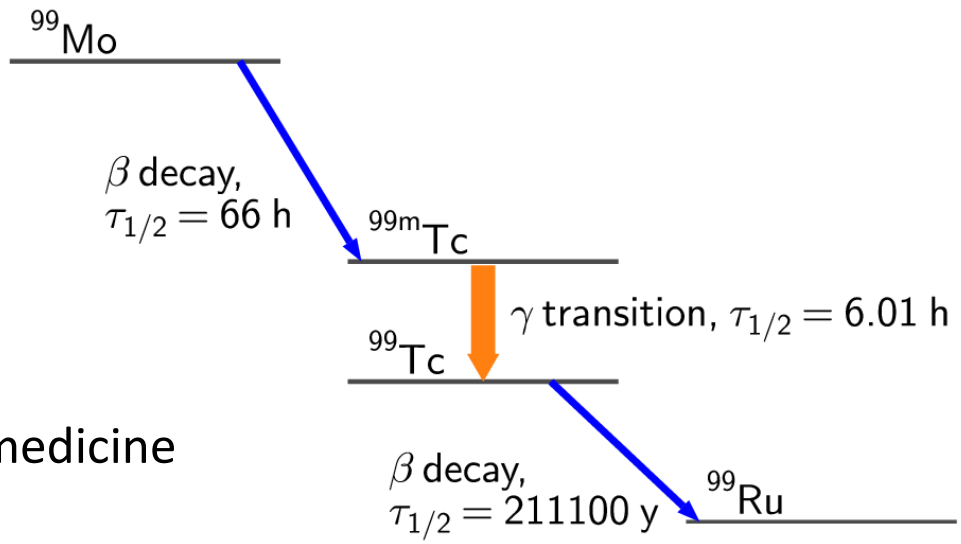


- CII is a new Canadian for-profit company
- Focus on new technology to supply $^{99}M/^{99m}Tc$

The Goal: reliable supply of ^{99m}Tc

^{99m}Tc:

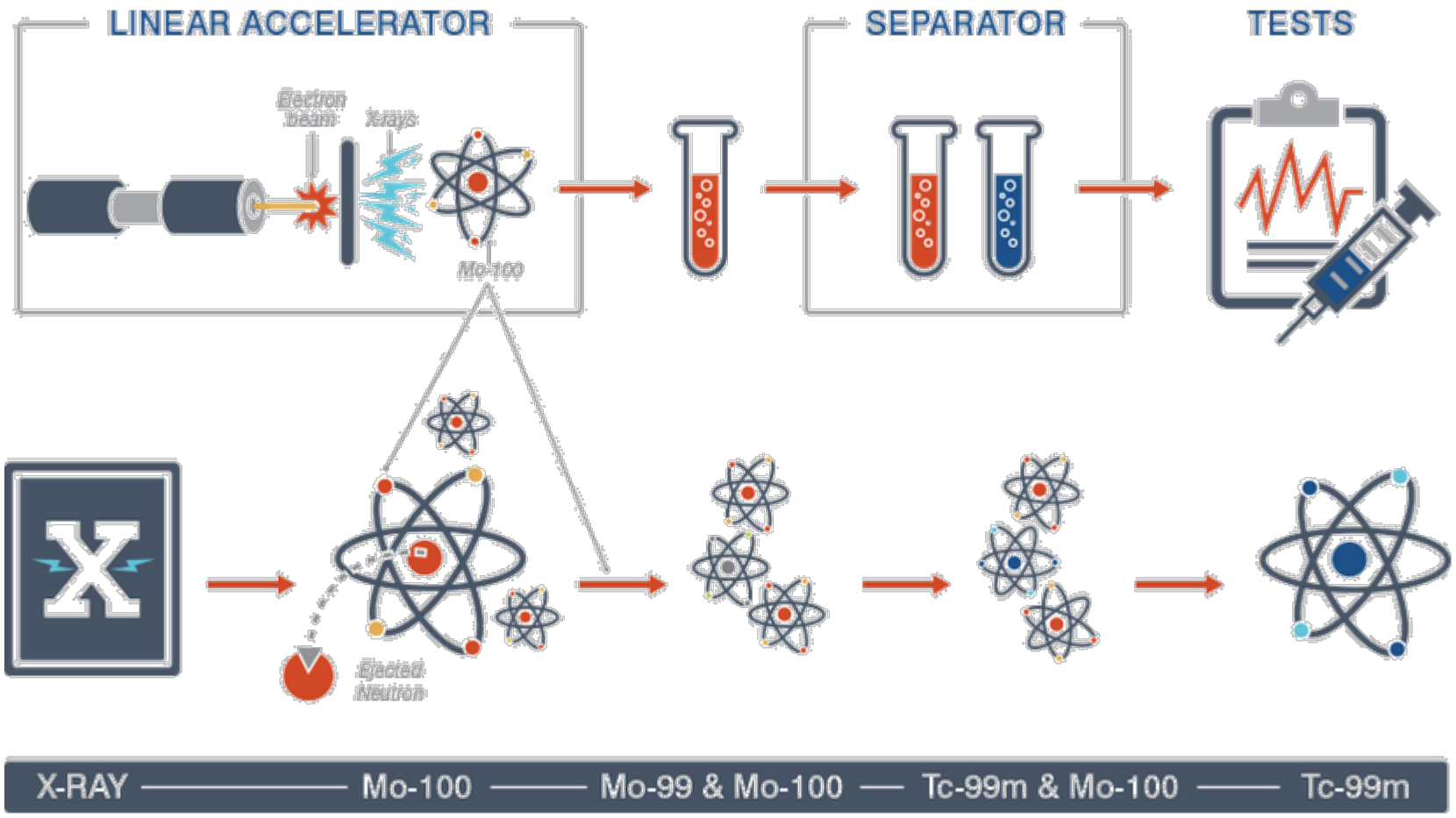
- 140 keV γ-ray
- Used for ~80 % of nuclear medicine diagnostic imaging
- Canada – about 5500 procedures per day



Supply Issues in Fission ^{99}Mo Production

- Full cost recovery and implication to radiopharmacy budgets (↑about 140%, 2009-16)
- Reactor age and reliability concerns
- Centralization of production locations
- Minimal technology diversification (fission)
- Processing capacity is fairly stagnant
- Long shipping distances with product loss and transport reliability issues
- Environmental concerns (nuclear waste, effluents)
- Security concerns (reactor and safety, HEU transport and storage, nuclear waste)

CII – Electron Accelerator Production



Why Electron Linacs?

- **Disadvantages:**
  - Lower cross-sections (electromagnetic vs nuclear interactions)
  - More difficult to make carrier-free radio-isotopes -> LSA ^{99}Mo
- **Advantages:**
  - Photons are more penetrating, allowing thicker targets and windows
  - Electron linacs are generally simple and reliable
  - Fewer reaction channels
    - Fewer undesired isotopes
    - Less radioactive waste (vastly less than fission!)
- **Relatively unexplored option!**
  - Few low-energy research electron linacs still operating

Proof of Concept

Canada Light Source Medical Isotope Project:

- Funded by NRCan NISP (2011 – 2013) and Saskatchewan
- Develop a fabrication method for ^{100}Mo targets
- Low-power testing (< 2 kW) of ^{100}Mo target to validate production yield estimates (done at NRC in Ottawa)
- Evaluate the quality of the LSA ^{99}Mo produced and the ^{99m}Tc separation process, performed by the Health Sciences Centre in Winnipeg
- Development of a suitable recycling process to recover the ^{100}Mo after irradiation and ^{99m}Tc separation for future targets

Pilot Production Facility

Canadian Light Source Medical Isotope Project:

- Install a 35 MeV 40 kW linac at the CLS
- Design & build bremsstrahlung converter and Mo target system
- Develop laboratory for target manufacture and recycling production facility for ^{100}Mo targets
- Irradiated targets shipped to Winnipeg Health Sciences Centre for ^{99}Mo dissolution and ^{99m}Tc extraction
- Exclusive license of technology to CII for commercialization

Isotope Linac and Target Assembly

Targets and Remote Handling

Target Holder with 9 disks

Remote handling

CII - Develop Commercial Production

- Develop high capacity generator for LSA ^{99}Mo
- Improve converter/target performance
- Develop preliminary facility designs for commercial production using 100kW electron linacs with multiple target stations
- Examine possible production of other isotopes
- Exploit international opportunities for technology

LSA Generator Options

Solvent extraction technology

- Applied for low specific activity neutron capture ^{99}Mo at many facilities around the world
- Evaluated specifically for Linac ^{99}Mo (CLS and Winnipeg HSC)

Solid-phase extraction with cartridge system

- Validated for cyclotron produced ^{99m}Tc extraction (TRIUMF, UofA)
- Validated for neutron capture ^{99}Mo (NRC Ottawa, NorthStar)

Thermal separation

- Under development

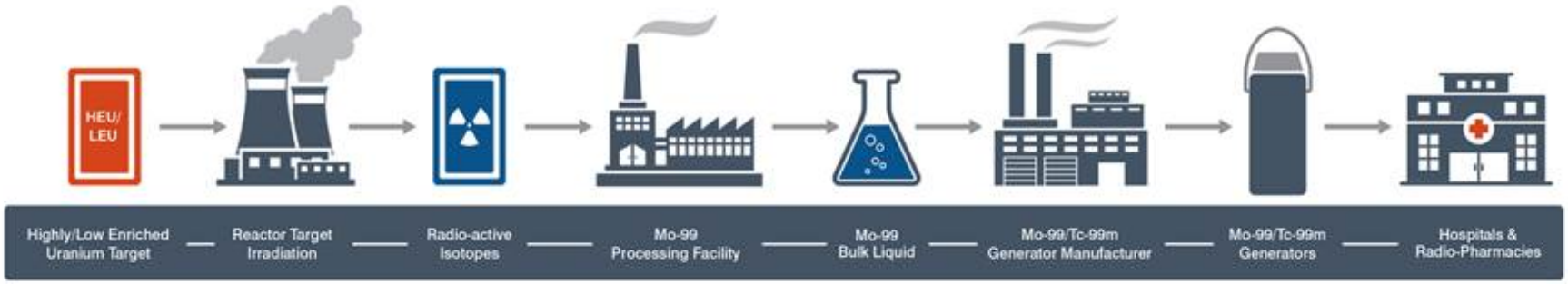
Gel columns

- Validated, with issues with market adoption

Others…

New ^{99}Mo Supply Paradigm

Current Reactor + Fission Paradigm



The New CII Supply Paradigm

Advantages of Linac ^{99}Mo Supply

- Use existing, proven technologies for irradiation and processing
- On-Off operations allow for great control in batch production of different isotopes and full flexibility to customize supply to client needs
- Easily scalable from single linac to multi-linac facilities
- Offers geographical proximity to clients -> lower product decay loss
- Capital, equipment and construction costs are lower
- Don’t need enriched uranium -> zero security costs
- Minimal radioactive waste -> low security, storage and remediation costs
- Licensing is much easier than for reactors and fission processing facilities
- A fully integrated supply chain allows for excellent costs control

CII's Linac Business Streams

- Integrated full cycle customer relationship – ^{99}Mo, generator supply, service and maintenance, and recycling
- Irradiation services and ^{99}Mo supply – as solid or liquid
- Generator provision for other LSA ^{99}Mo sources
- Turn-key package including linacs, targets and technology support
- Other medical isotopes and support services

CII - Strengths for Global Supply

- Innovative, customer-responsive technology
  - Technology diversification
  - Facility siting decentralization
- Commitment to security and environmental consciousness
- Fully integrated processes with excellent costs control
- Accessible and scalable technologies