Innovative Approach for Sustainable and Low-Waste Production of ^{99}Mo for Radiodiagnostics using an Accelerator-Based Neutron Source

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Introduction and Motivation

Approximately 80% of the world's nuclear medicine examinations, totaling about 40 million annually, utilize ^{99m}Tc, with Europe responsible for 25% of this demand. In Germany alone, nearly 60,000 examinations are conducted weekly, consuming almost 10% of the global yearly supply of ^{99m}Tc. The objective of this project is to explore the production of 2400 Ci of ^{99}Mo over a 6-day period, aiming to meet the demand for ^{99m}Tc in Germany.

Conventional Method

- High neutron flux reactors
- Production by ^{235}U fission
- Complex radiochemical processing
- High radioactive waste generation
- Proliferation issues

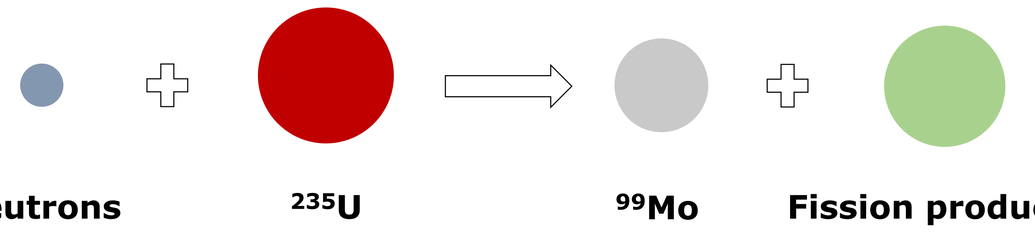


Figure 1. Production of ^{99}Mo through fission of ^{235}U

Innovative Approach

- High-current accelerator-based neutron source (HiCANS)
- Production by (n, γ) reaction
- Simplified radiochemical processing
- Reduced radioactive waste generation
- No proliferation issues

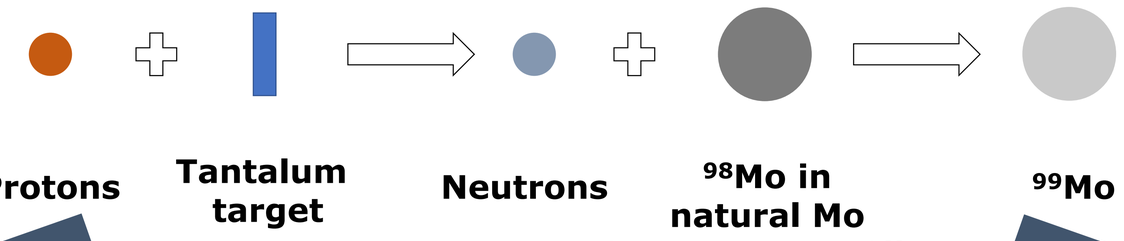
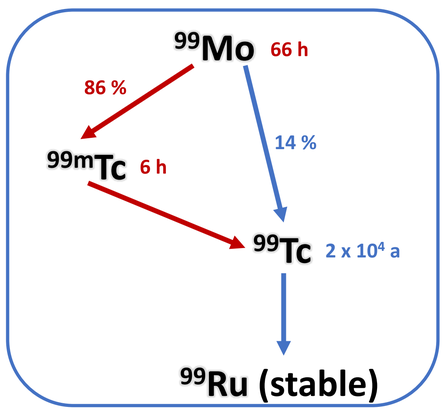


Figure 2. Alternative approach for the production of ^{99}Mo

Isotope extraction and delivery system

Adjustment and modification of known separation methods for handling of irradiated ^{99}Mo samples

- Focus on general ^{99}Mo/^{99m}Tc generator system
  - Alumina (Al_2O_3) column
- Adsorption behavior of ^{99}Mo, elution efficiency of ^{99m}Tc
- Optimization and purification for medical use



Modification of chemical separation of ^{99m}Tc from ^{99}Mo

Adjustment of the ^{99}Mo/^{99m}Tc generator system

- Simple operation
- Fast process
- Low waste production
- Low chemical treatment of the sample

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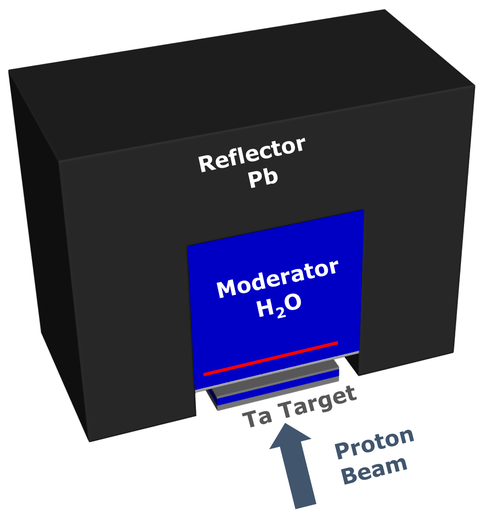
Target Moderator Reflector design

Development of a concept for ^{99}Mo production based on the current Target-Moderator-Reflector (TMR) design of the HBS project

- Neutron generation by 70 MeV protons impinging on a tantalum target (3 kW/cm^2)
- Suitable moderator and reflector material
- Activation of natural Mo sample by thermal and **epithermal** neutrons



Optimization of all parameters to achieve a total activity of 2400 6-day Ci of ^{99}Mo

- Experimental validation of Monte Carlo simulation codes
  - **PHITS**, FLUKA
- TMR design for maximizing the integral epithermal flux
- Automatic handling and transport system for ^{99}Mo-irradiated samples

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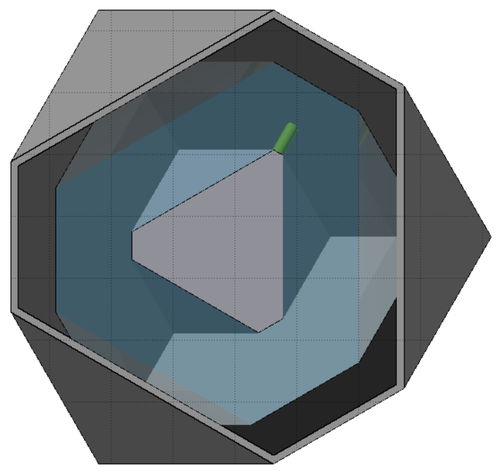
Radiation protection and shielding

Development of a concept on how to manage and dispose of the activated materials

- Shielding for the prompt irradiation dosage
- Suitable material composition for safety and handling
- Extraction mechanism of the TMR out of the shielding
- Storage and disposal of activated materials



Development of a Monte Carlo model for radiation field calculations

- FLUKA Model
  - Scoring of the particle fluxes (neutron, proton, photon, …)
  - Calculation of the ambient does rates
- Comparison to reactor based irradiation scenarios

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