Sensitivity Analysis of Molybdenum-99 Production in the Oregon State TRIGA Reactor

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Target Designs

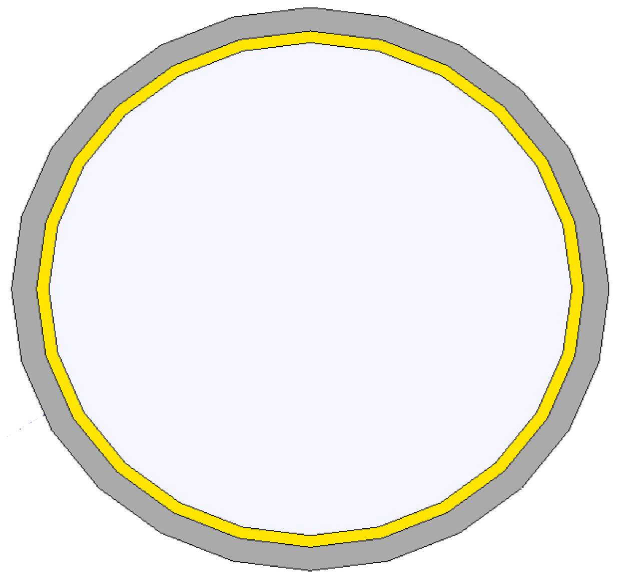


Fig 1: Classical Centichem design

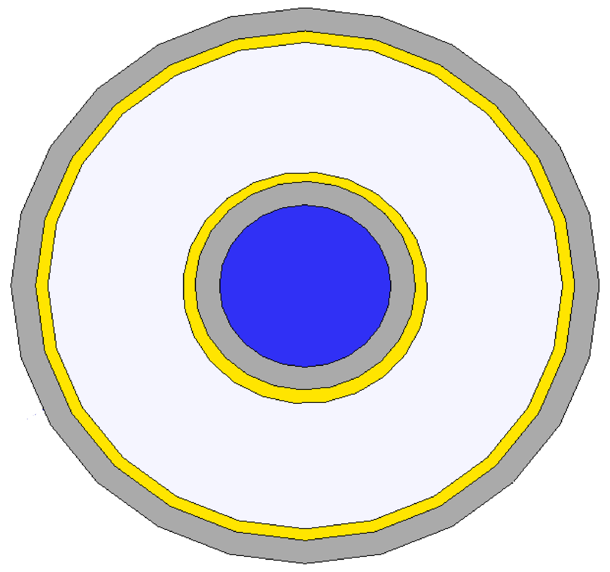


Fig 2: Target design (b)

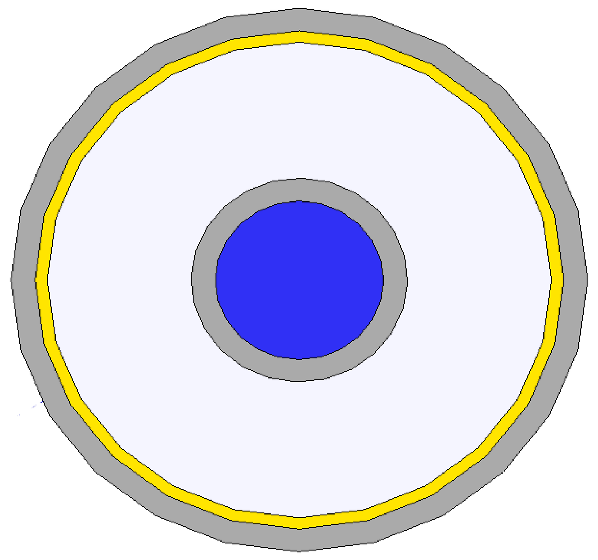


Fig 3: Target design (c)

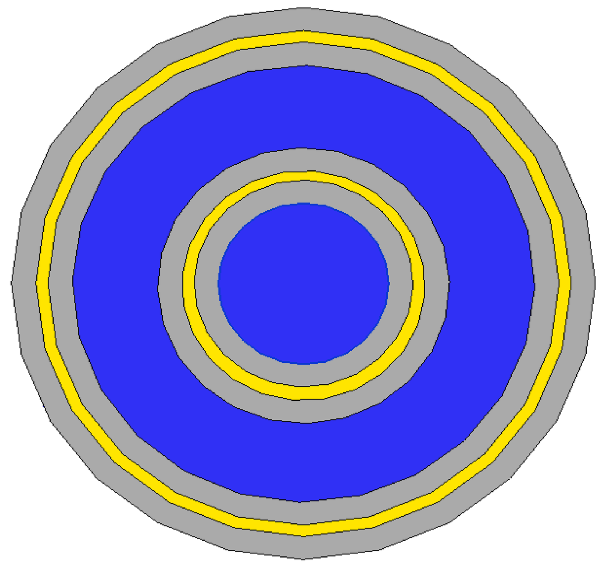


Fig 4: Target design (d)

Background

- Molybdenum-99 production is limited to only a few reactors in the world.
- Molybdenum-99 decays to ^{99}Tc, an isotope used in millions of medical diagnostic procedures a year.
- The US consumes about half of the world's supply of the ^{99}Tc, it produces none.
- Determining a viable design that could be produced in the United States would increase ^{99}Mo production and make the isotope more available to consumers.

Clad Material   Target Fuel

Air   Water

Method

MCNP5 was employed to simulate the production of ^{99}Mo in the Oregon State University TRIGA Reactor (OSTR). By using MCNP as a tool to simulate ^{99}Mo production, it could be determined which design produced the most ^{99}Mo. A deck with a core configuration reflecting the operational core in the OSTR (fig. 6) was used for each simulation. ^{99}Mo targets were placed in the outermost ring of the core, with the targets filling all available positions in this region. In this manner it could be determined which positions in the core are the most optimal for ^{99}Mo production.

Design

The primary goal of this work was to determine a more efficient design for LEU production of ^{99}Mo. While each target design varied substantially in the layout of materials, the fueled height, clad thickness, and uranium enrichment all remained constant (table 1). The design alterations were limited to inner geometry changes, material changes, and variations in fuel mass. To aid in ^{99}Mo production, an inner annulus filled with water was added to all modified designs. Additionally, the target fuel mass was varied for each target such that an optimal target mass—producing large amounts ^{99}Mo, but with low self-shielding—could be determined. The fuel was distributed to the inner annulus in designs (b) and (d) to reduce the effects of self shielding.

Table 1: Parameters of ^{99}Mo Target Designs

Active Height	55.65 cm
Clad Thickness	.0508 cm
Clad Material	variable
Fuel Material	Uranium Metal
Fuel Enrichment	20%
Fuel mass	variable

The cladding material for designs (b) (c) and (d) were all varied to explore the sensitivities of the designs to the construction materials. Beryllium was used to boost the flux, while aluminum was used for its neutron transparency.

Results

The results from MCNP5 generally support the design changes made to the ^{99}Mo targets. The effect of adding the inner water filled annulus (design (b)) alone boosts the ^{99}Mo production ~60%, and when coupled with a cladding change boosts production twofold. Results confirm that the Beryllium sleeve clad does boost the flux in the modified target elements. However, effects of beryllium do not appear to be as beneficial as initially predicted, as an aluminum clad target produced ^{99}Mo at a similar rate as a beryllium clad target.

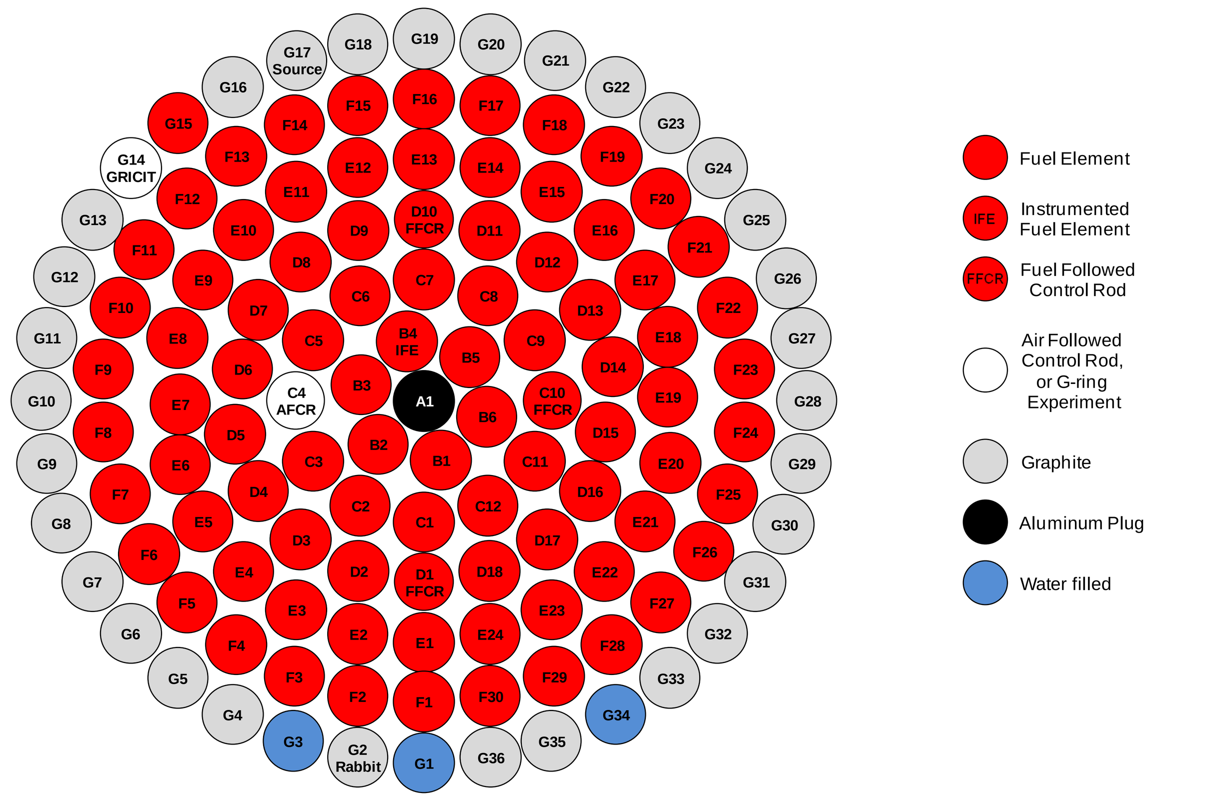


Fig 6: TRIGA core model. Outermost graphite ring to be replaced with ^{99}Mo production targets

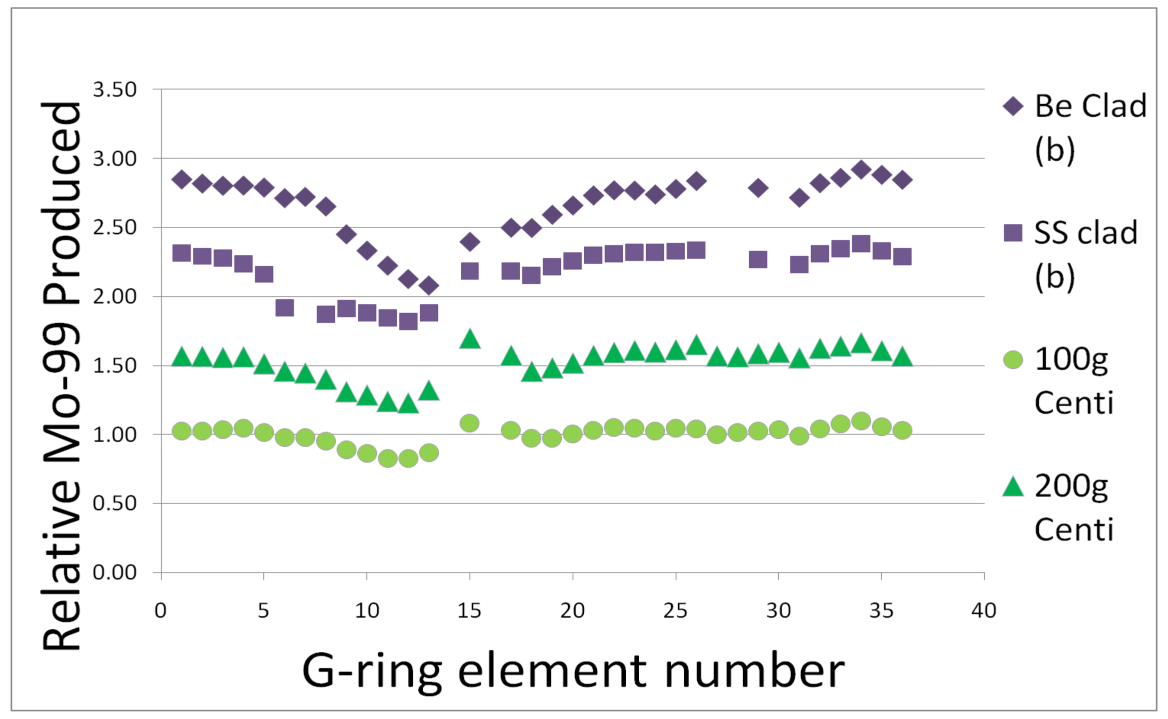
Design (d) was created to optimize ^{99}Mo production with a beryllium clad material. It was determined that even with the addition of water the design had little change compared to (b). However, this design produced less ^{99}Mo compared to (b) when clad with stainless steel, amplifying the adverse effects of this material.

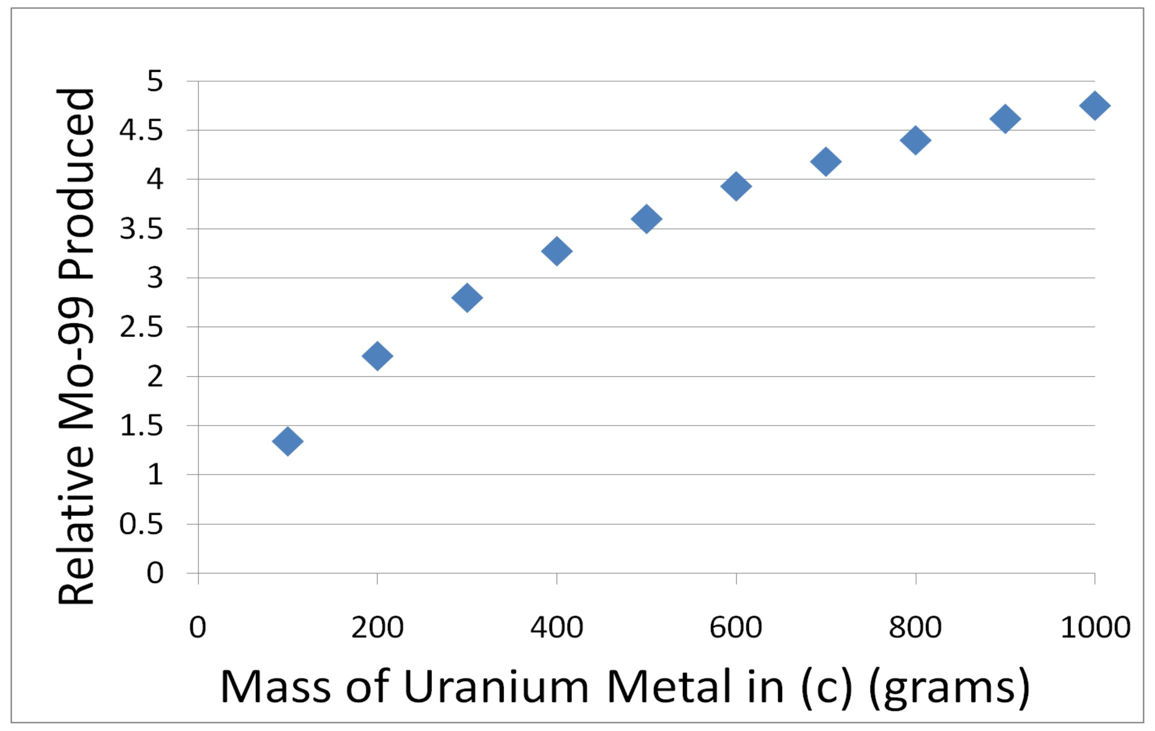
Conclusion

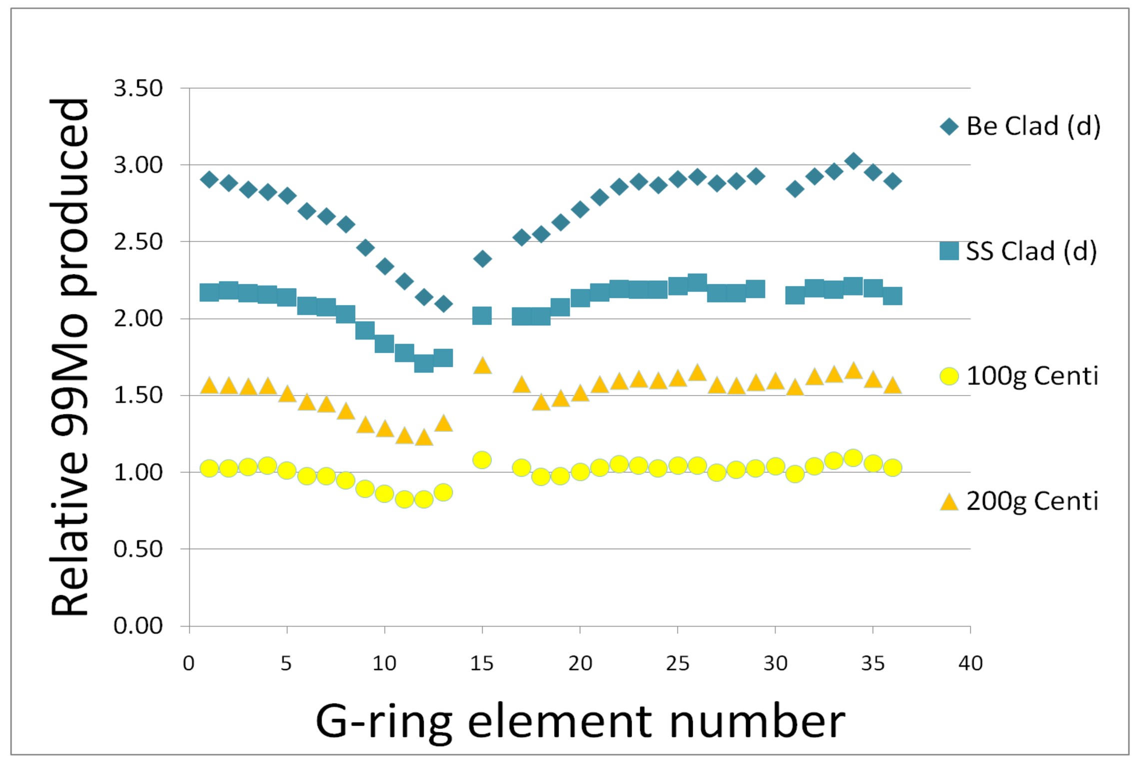
The geometric and material changes made to the ^{99}Mo target both appear to significantly boost the production of ^{99}Mo. The MCNP5 calculations support these findings. Should this design be found viable, a domestic ^{99}Mo source could be one of the several small research reactors that exist throughout the world.

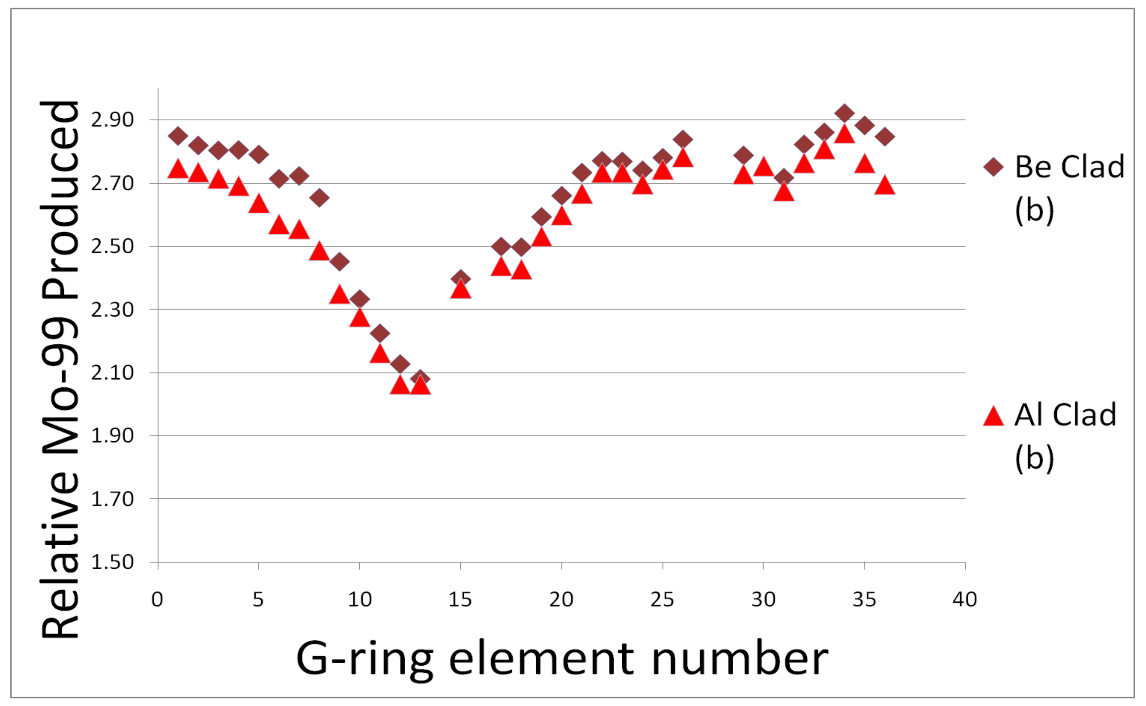
Future Work

- Explore the manufacturing feasibility of each design
- Perform a sensitivity analysis on the finalized target design
- Determine power loading in different regions of the target
- Perform a thermal-hydraulic assessment of the target.









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