Australian Government

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UNIVERSITY OF WOLLONGONG AUSTRALIA

A new uranium target design for increasing the sustainability of ^{99}Mo production

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Science. Ingenuity. Sustainability.

Current target design

Solid Uranium Target (LEU)

Plate type target

- Uranium –aluminium alloy UAlx
- Density – 1.4 gU/ cm^3
- Requires target destruction to extract ^{99}Mo
- Enrichment < 20%

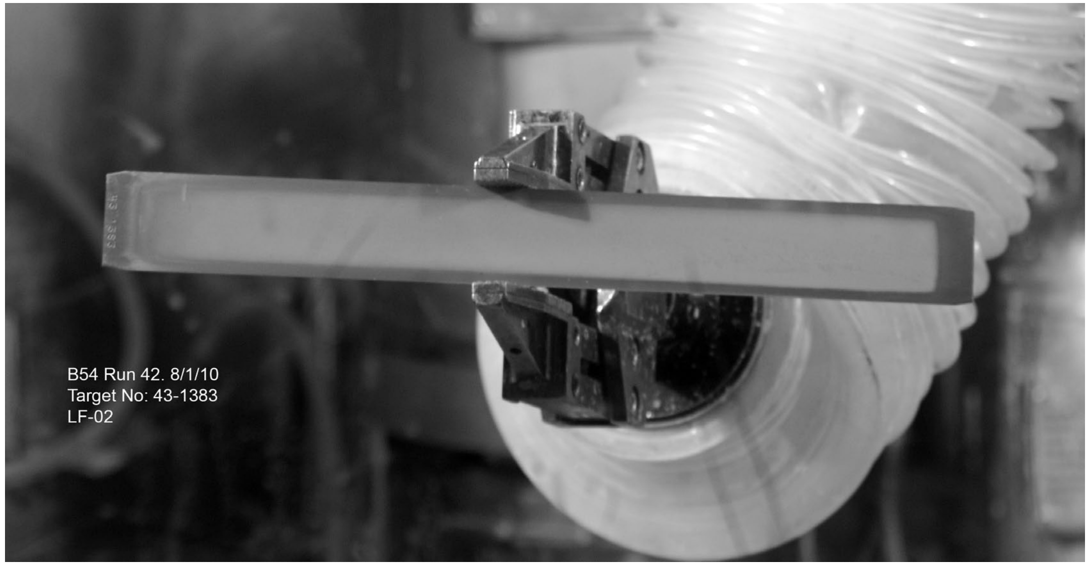

Figure 1

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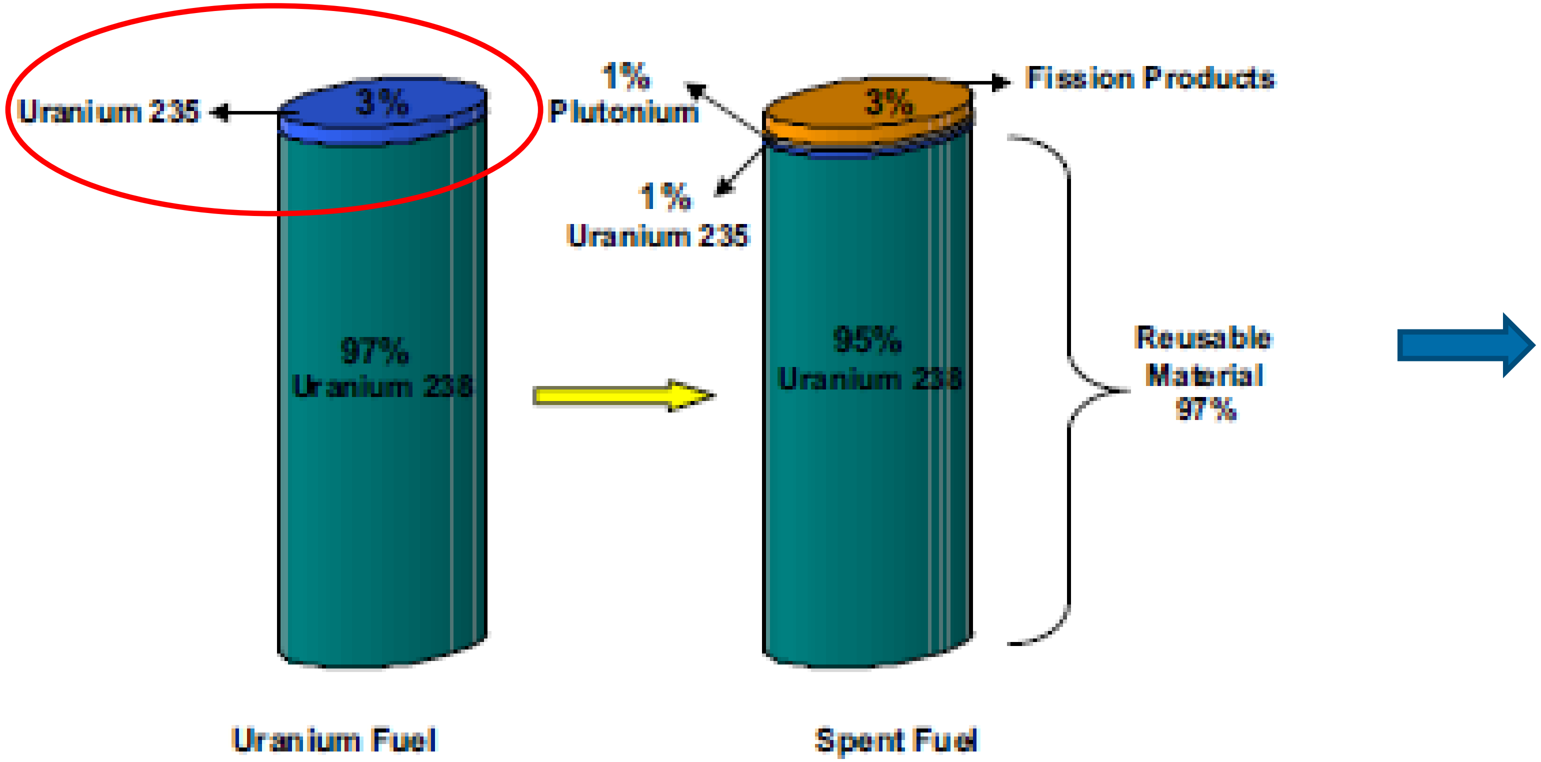
Wastes arising from production



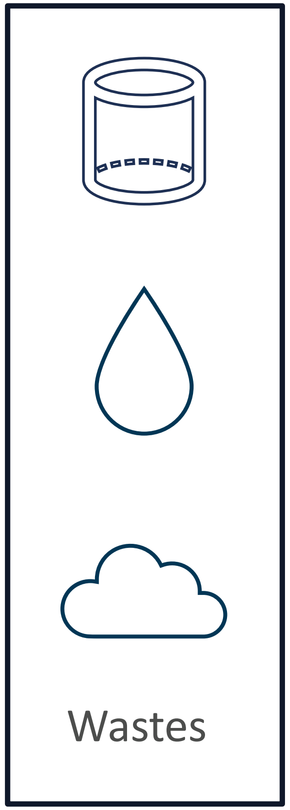


Figure 2 (Silverio, Lamas, 2011)

- Solid, liquid and gas van derMarcket al., 2010
- Estimated that 10-20 times less ^{235}U is burned up in ^{99}Mo production targets as compared with spent reactor fuel Beyer et al., 2016

HEU vs LEU Targets

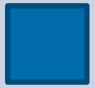
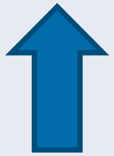
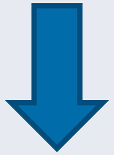
	Highly Enriched Uranium	Low Enriched Uranium
^{99}Mo output		
Proliferation concerns		
Radioactive waste volume		

Table 1

Reusable targets – using fission recoil

Journal of Radioanalytical and Nuclear Chemistry (2019) 319:1291–1300
https://doi.org/10.1007/s10967-019-06433-9

Check for updates

A UO_2-based salt target for rapid isolation of fission products

Jacquelyn M. Dorhout[1,2] · Marianne P. Wilkerson[2] · Kenneth R. Czerwinski[1]

Mo-99 2016 Topical Meeting on
Molybdenum-99 Technological Development

September 11-14, 2016
The Ritz-Carlton
St. Louis, Missouri

Irradiation Capsules with Suspended LEU UO_2 Particles for ^{99}Mo Production.

E.E. Pasqualini, S. Navarro, G. Chetri, N. Gonzalez and J.C. Furnari
Nuclear Nanotechnology Laboratory, GAATN.
Atomic Energy National Commission, CNEA
Constituyentes Atomic Center, CAC
Av. General Paz 1499
(B1650KNA) San Martín
Buenos Aires, Argentina

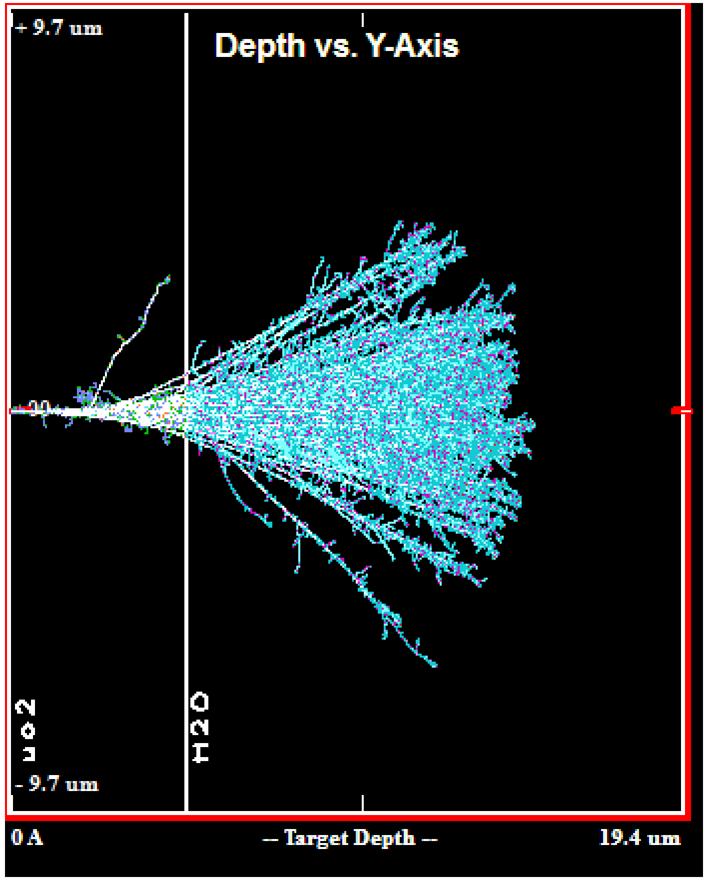


Figure 3 (Pasqualini, 2016)

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Porous reusable UO_2 targets

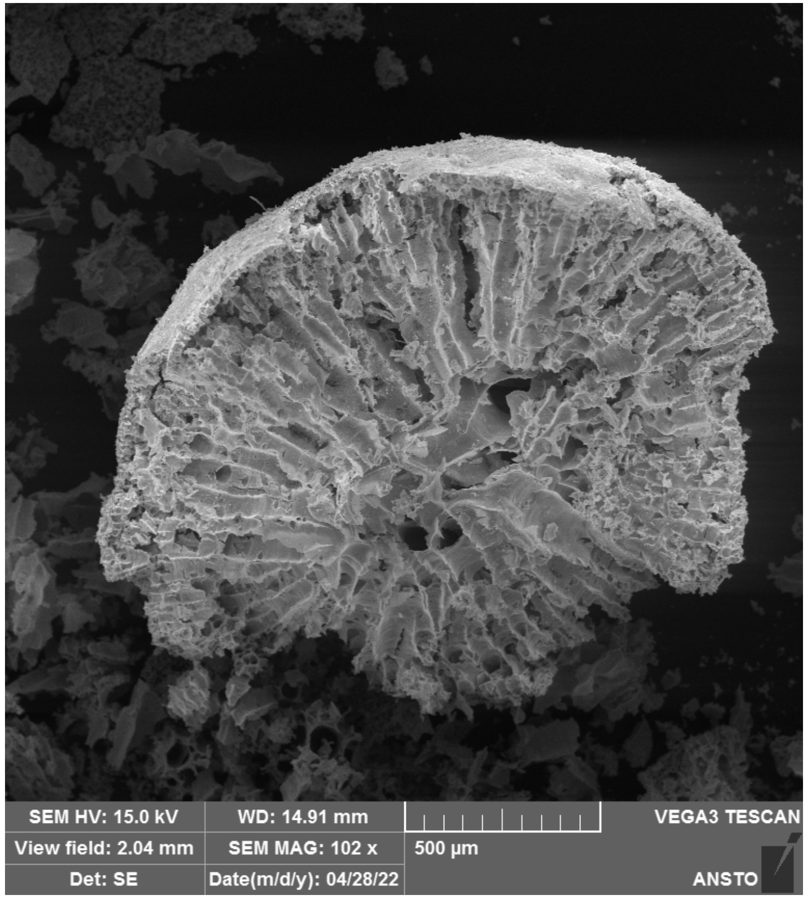

Figure 5

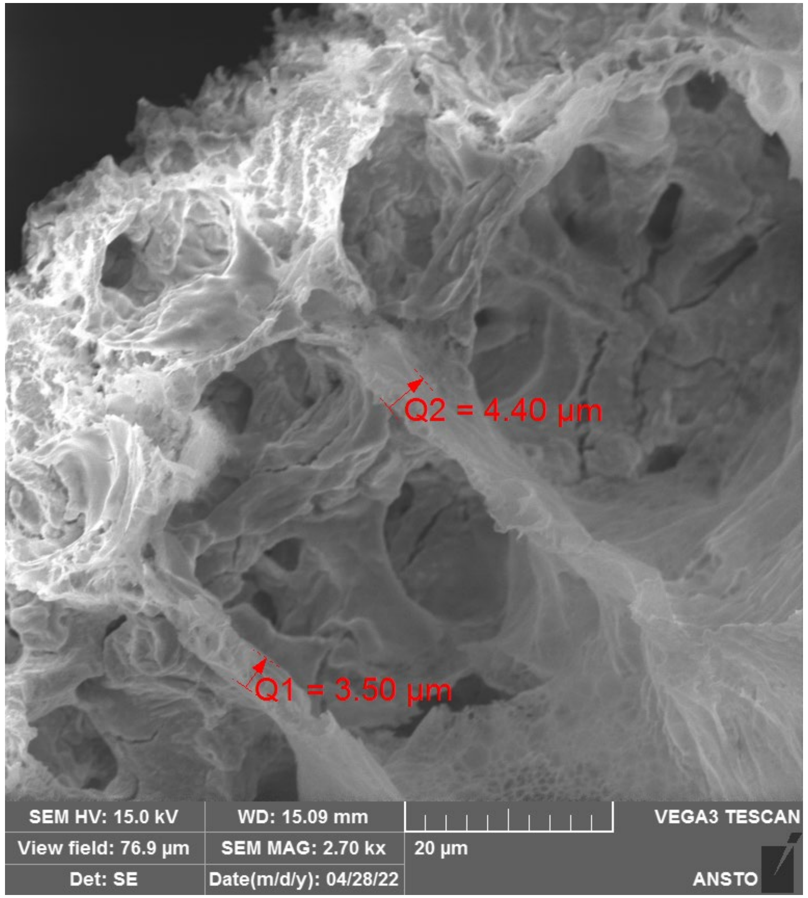

Figure 6

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MCNP6.2: Reusable targets – ^{99}Mo output

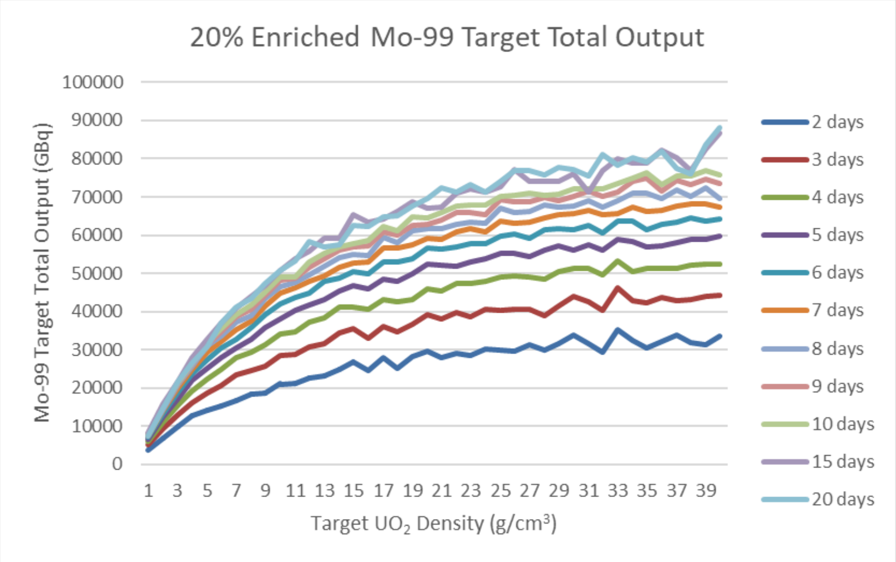

Figure 7

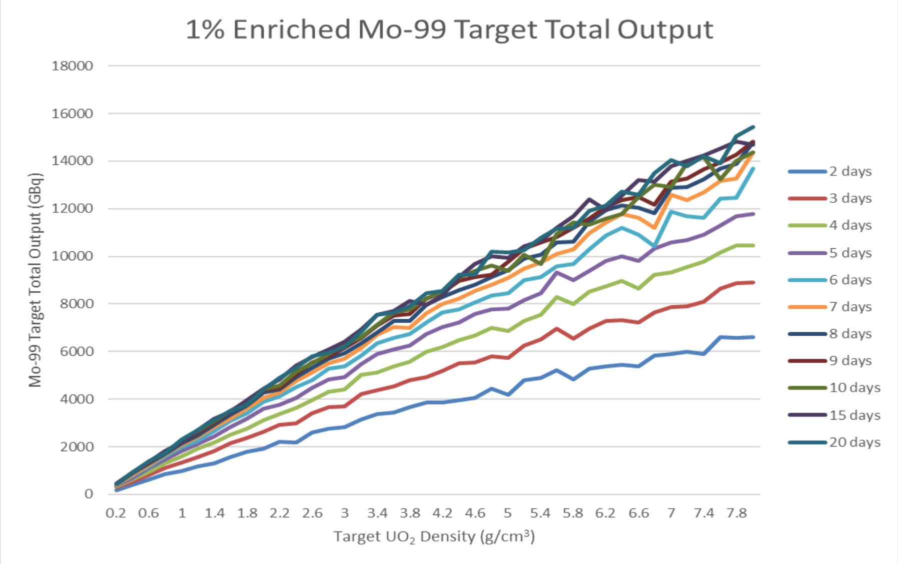

Figure 8

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Sustainable targets - the maths slide

$$\varepsilon_{\text{targ}} = \frac{{}^{99}\text{Mo produced (GBq)}}{{}^{235}\text{U in target (g)}} = \frac{A_{\text{T}}\,({}^{99}\text{Mo})}{m_{\text{T}}\,({}^{235}\text{U})} \quad (1)$$

$$\varepsilon'_{\text{targ}} = \frac{{}^{99}\text{Mo produced (GBq)}}{{}^{235}\text{U}_{\text{b}}\ \text{(g)}} = \frac{A_{\text{T}}\ \text{(GBq)}}{{}^{235}\text{U}_{\text{b}}\ \text{(g)}} \quad (2)$$

$$S_{\text{targ}} = \frac{A_{\text{T}}^2}{{}^{235}\text{U}_{\text{T}} \cdot {}^{235}\text{U}_{\text{b}}}\,(\text{Bq}^2.\text{g}^{-2}), \quad (3)$$

where A_{T} is a predefined amount of ^{99}Mo desired to be produced in the irradiation, $^{235}\text{U}_{\text{T}}$ is the total amount of ^{235}U in the target before the irradiation, and $^{235}\text{U}_{\text{b}}$ is the amount of ^{235}U burned up in the irradiation.

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MCNP6.2: Reusable targets - sustainability

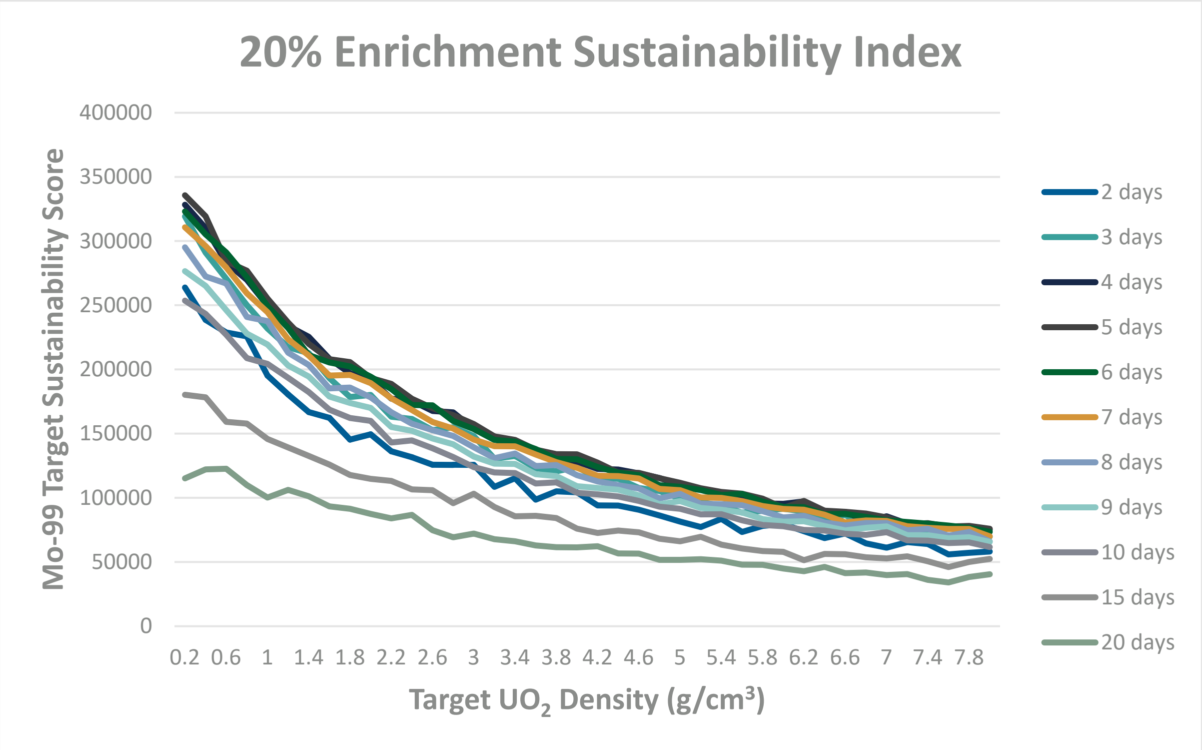

Figure 9

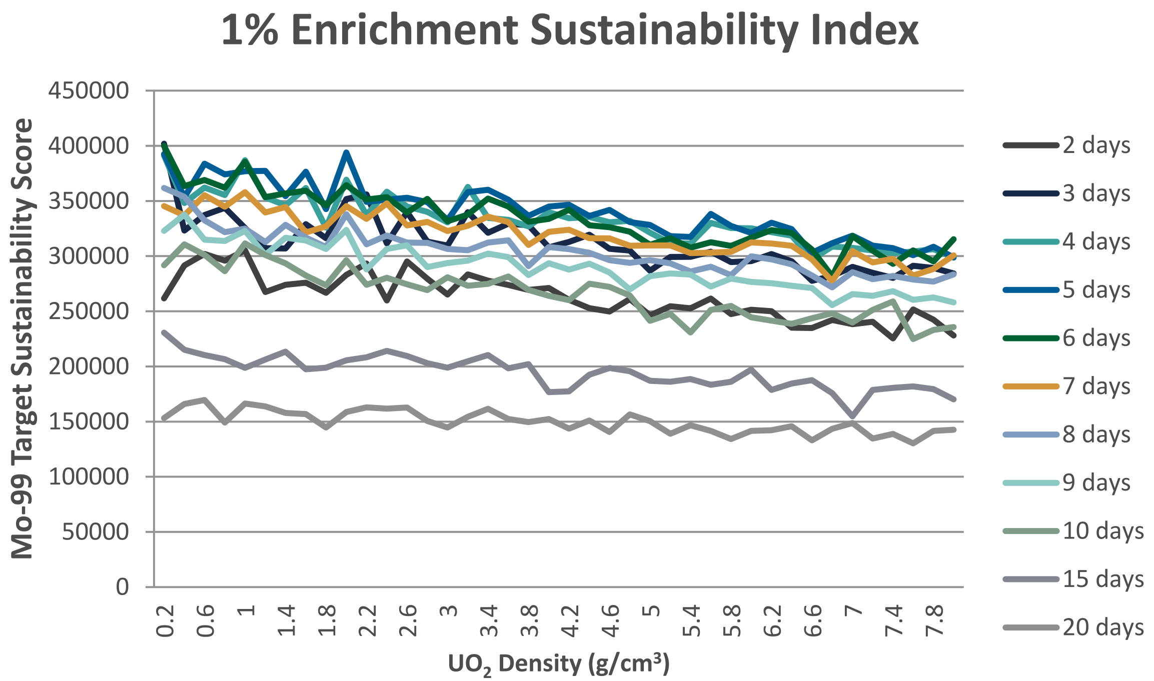

Figure 10

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MCNP6.2: Reusable targets - Geometry

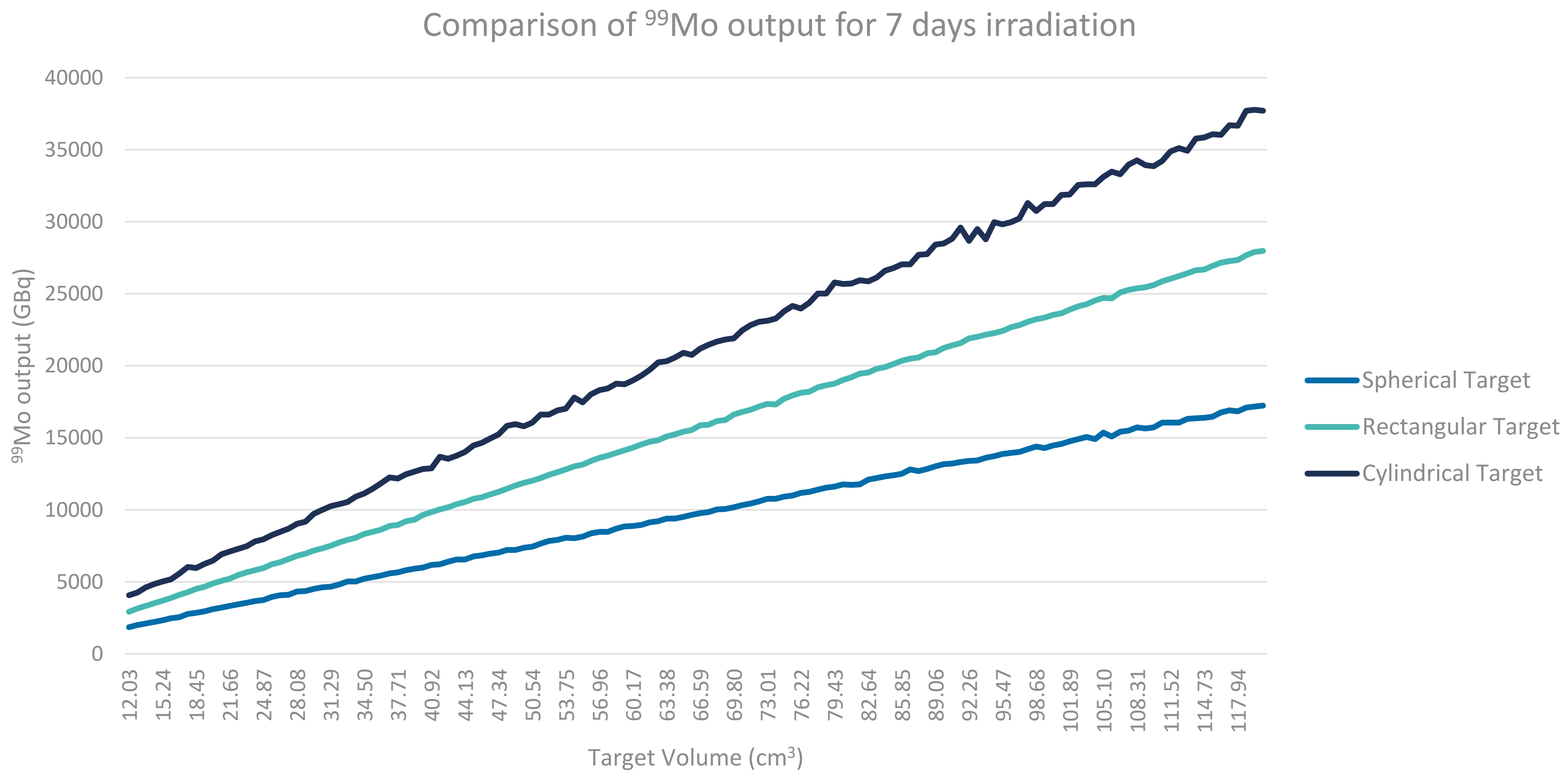

Figure 11

MCNP6.2: Reusable targets – ^{239}Pu

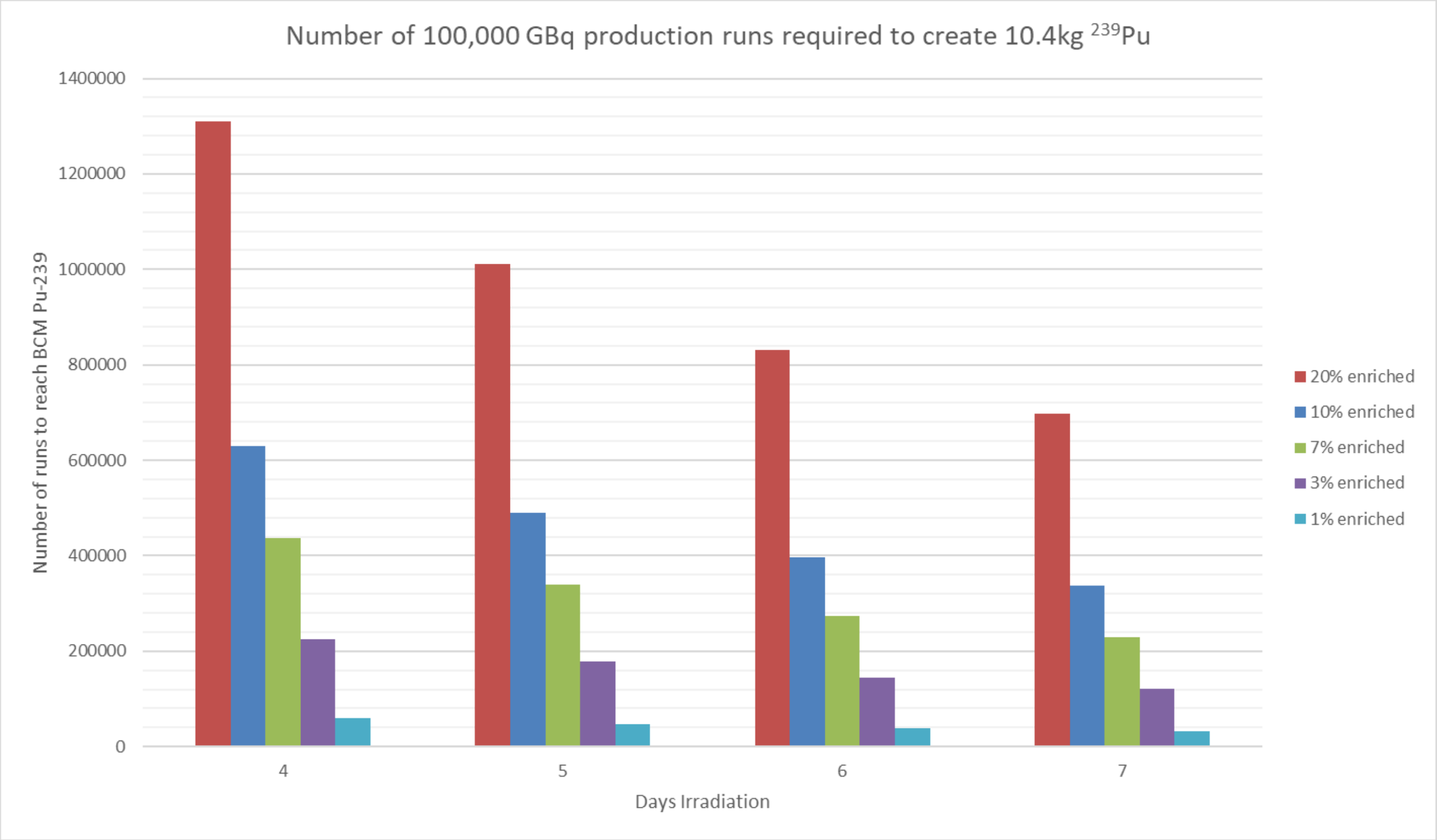

Figure 12

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MCNP6.2: Reusable targets – CeO_2

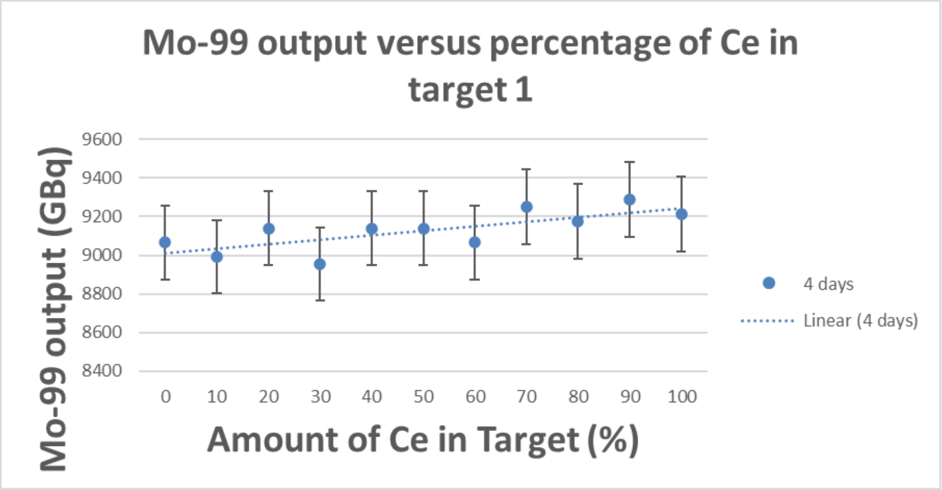

Figure 13

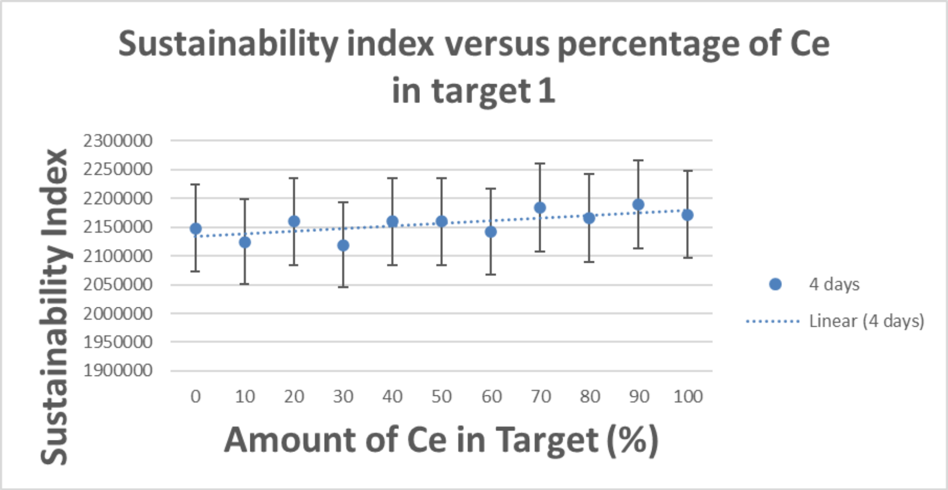

Figure 14

MCNP6.2: Reusable targets – ^{239}Pu

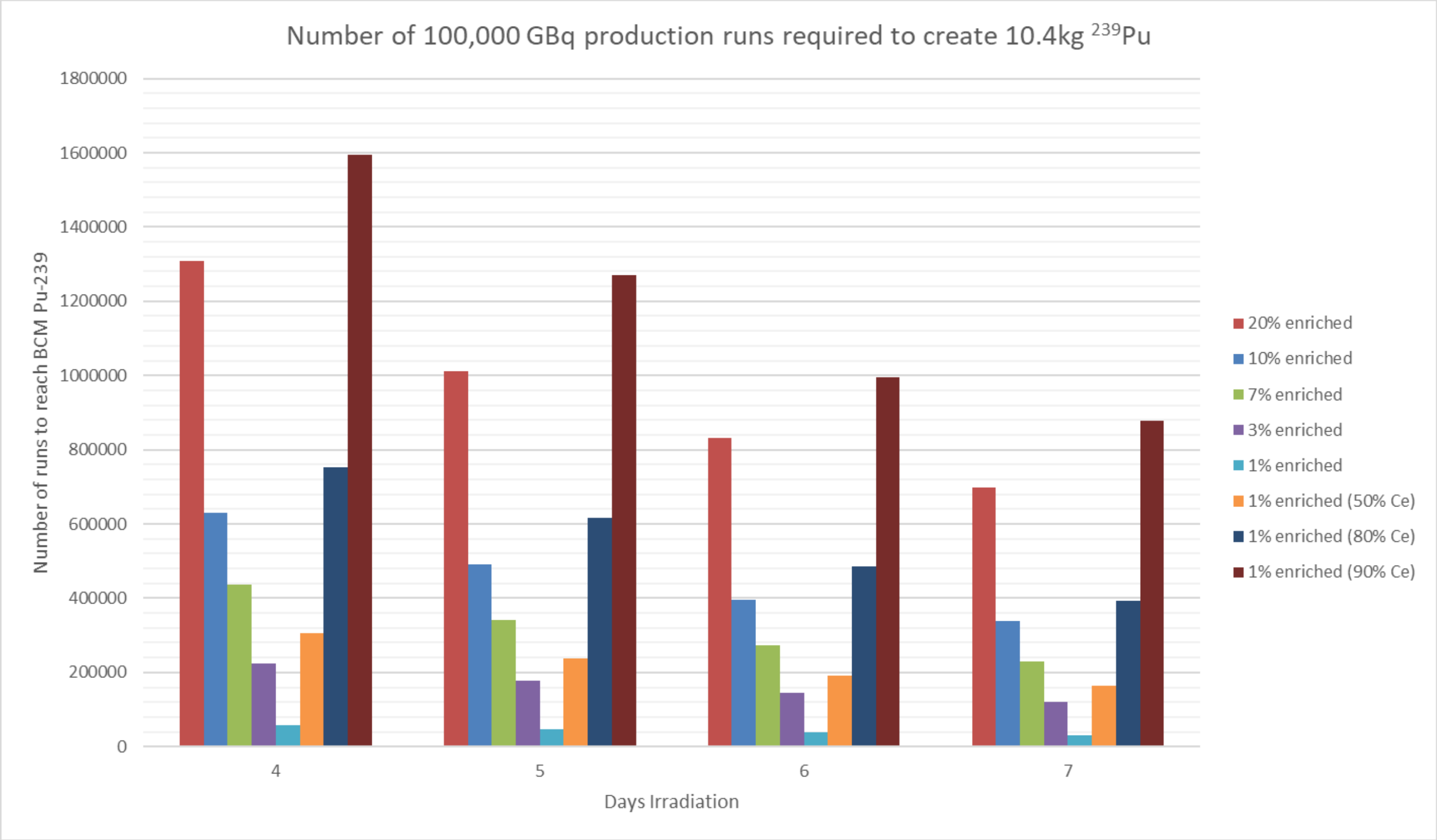

Figure 15

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Conclusions

- Reusable porous UO_2 targets are possible
- 1% enriched targets are much more sustainable than LEU
- Target output is greatly affected by geometry and cylindrical targets are the optimal for ^{99}Mo output
- Substitution of $^{238}UO_2$ with CeO_2 lowers ^{239}Pu levels significantly
- Possible to re-use the targets for multiple irradiations

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- Tim Ablott, ANSTO.
- Gordon Thorogood, ANSTO.

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