In the name of Allah

the most beneficent the most merciful

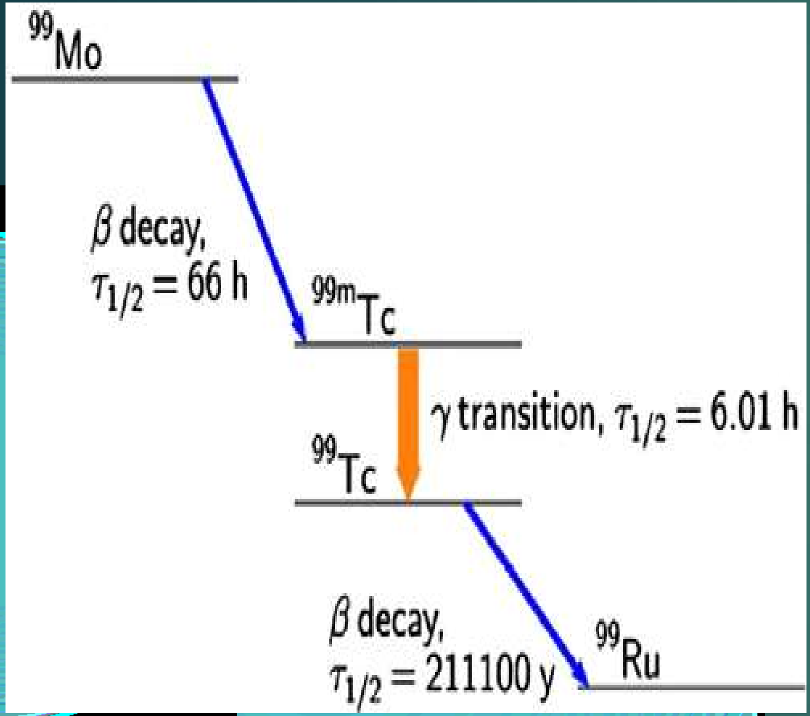
GEOMETRY OPTIMIZATION OF URANYL NITRATE LIQUID TARGET SYSTEM FOR ^{99}Mo

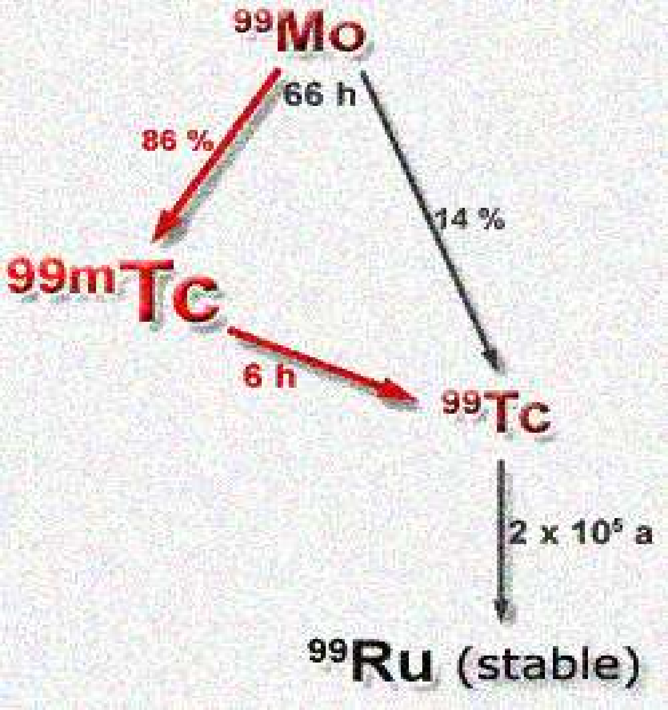
Z. GHOLAMZADEH, S. MOHAMMADI,

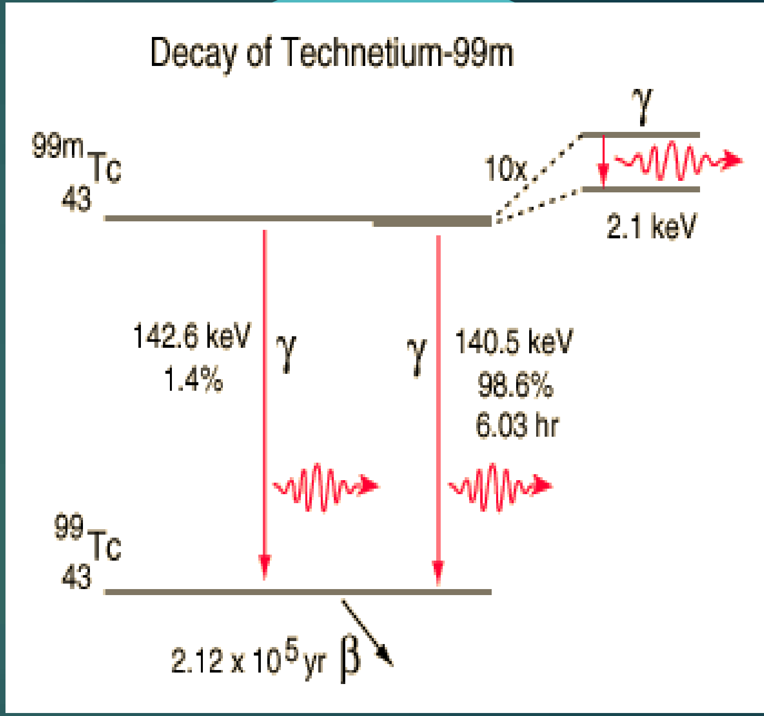
S.M. MIRVAKILI, F. FAGHIHI

May 2017

^{99}Mo AND ^{99m}Tc DECAY CHART







GLOBAL ^{99}Mo SUPPLY CHAIN

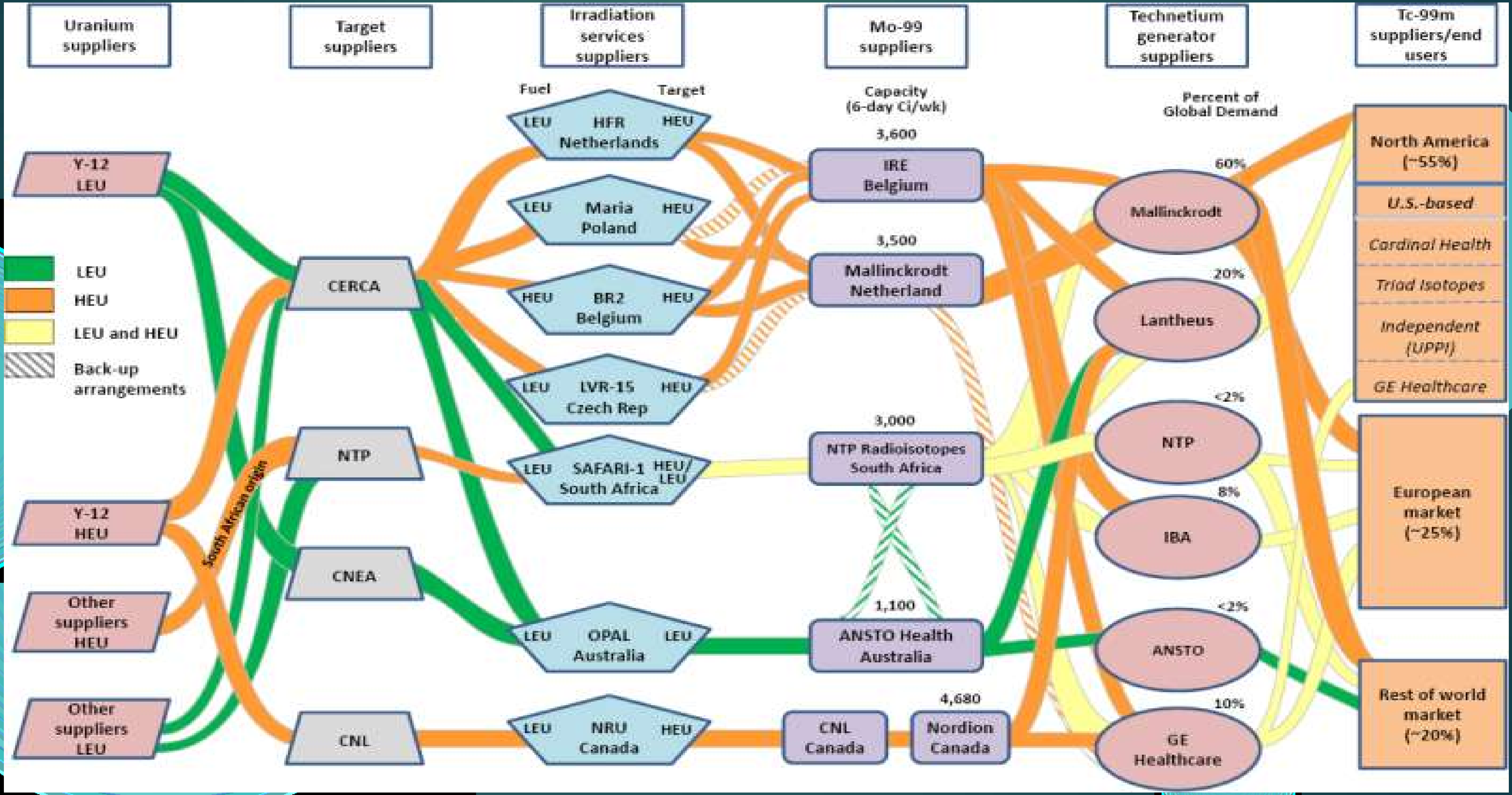
Limited suppliers involved in the global manufacture of **Mo-99**

8 main reactors producing medical isotopes

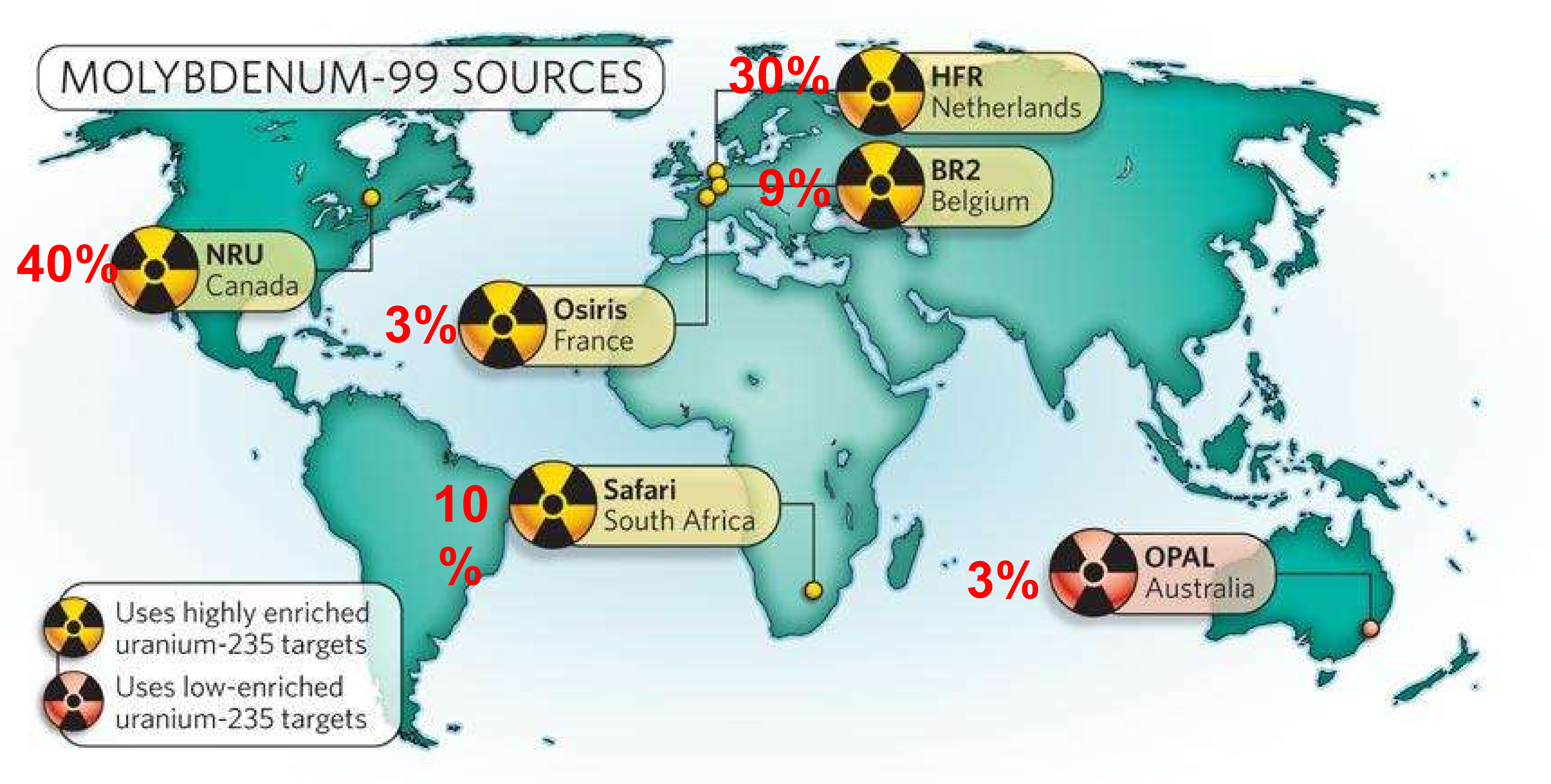
5 Mo-99 processing facilities

6 generator manufacturing facilities

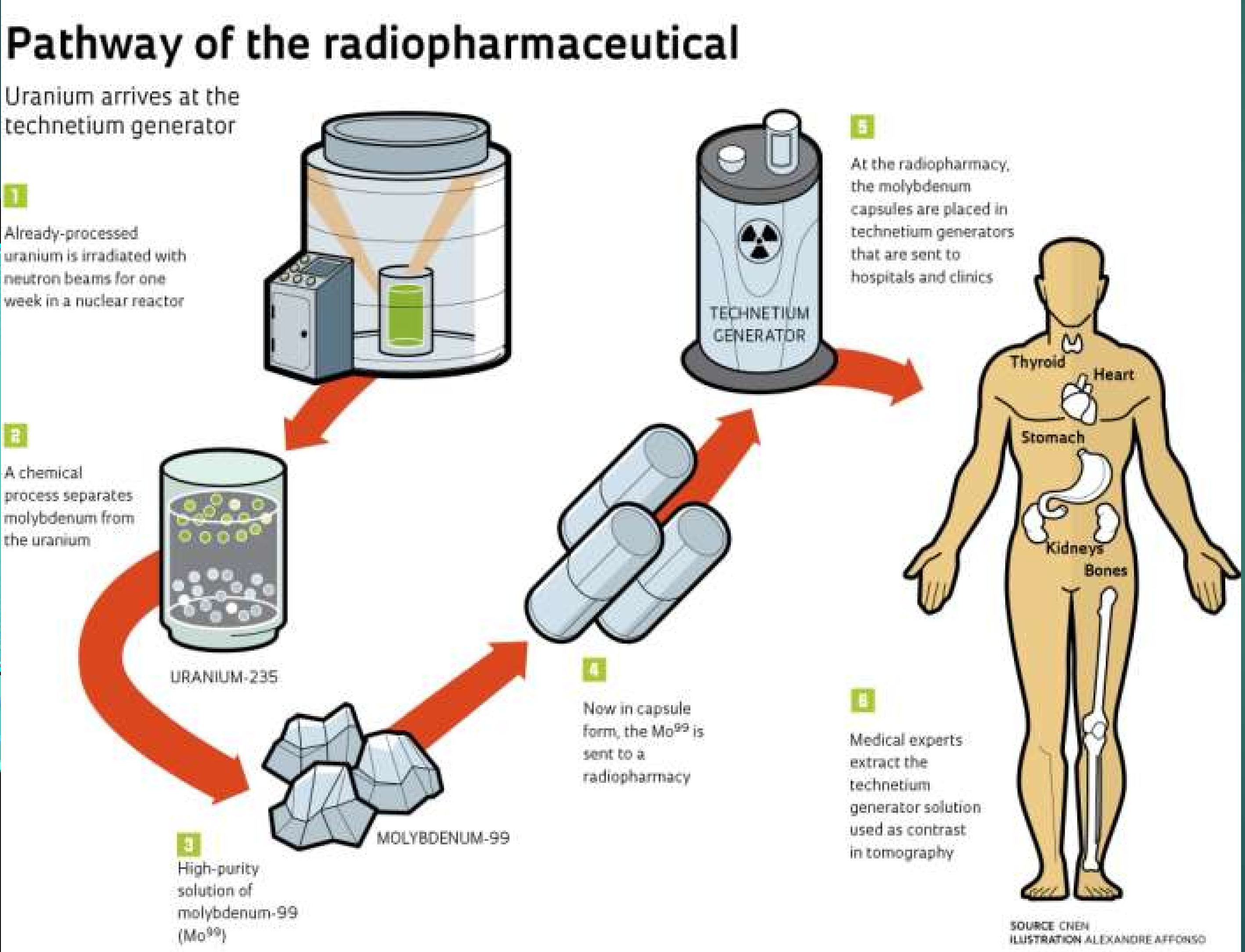
GLOBAL ^{99}Mo SUPPLY CHAIN



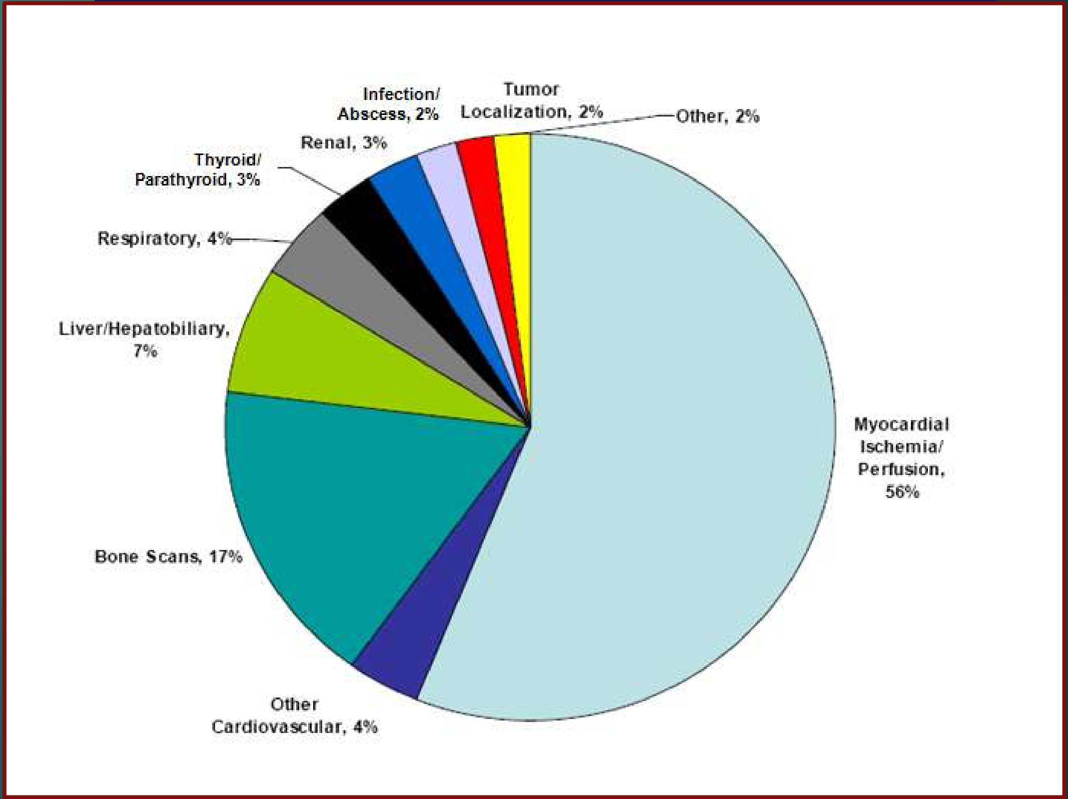
GLOBAL ^{99}Mo SUPPLY CHAIN



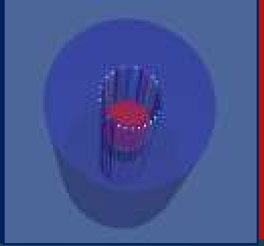
^{99}Mo / ^{99m}Tc APPLICATIONS

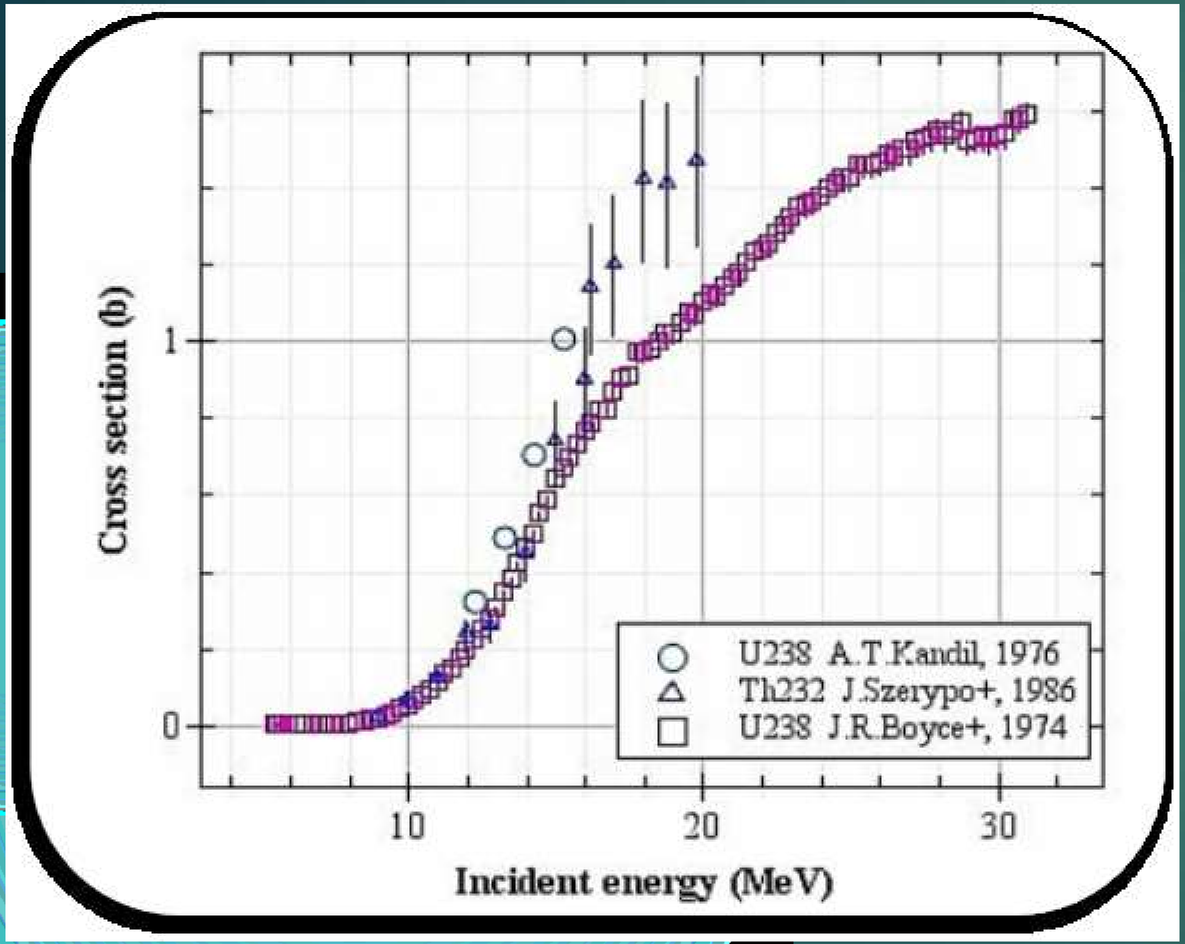


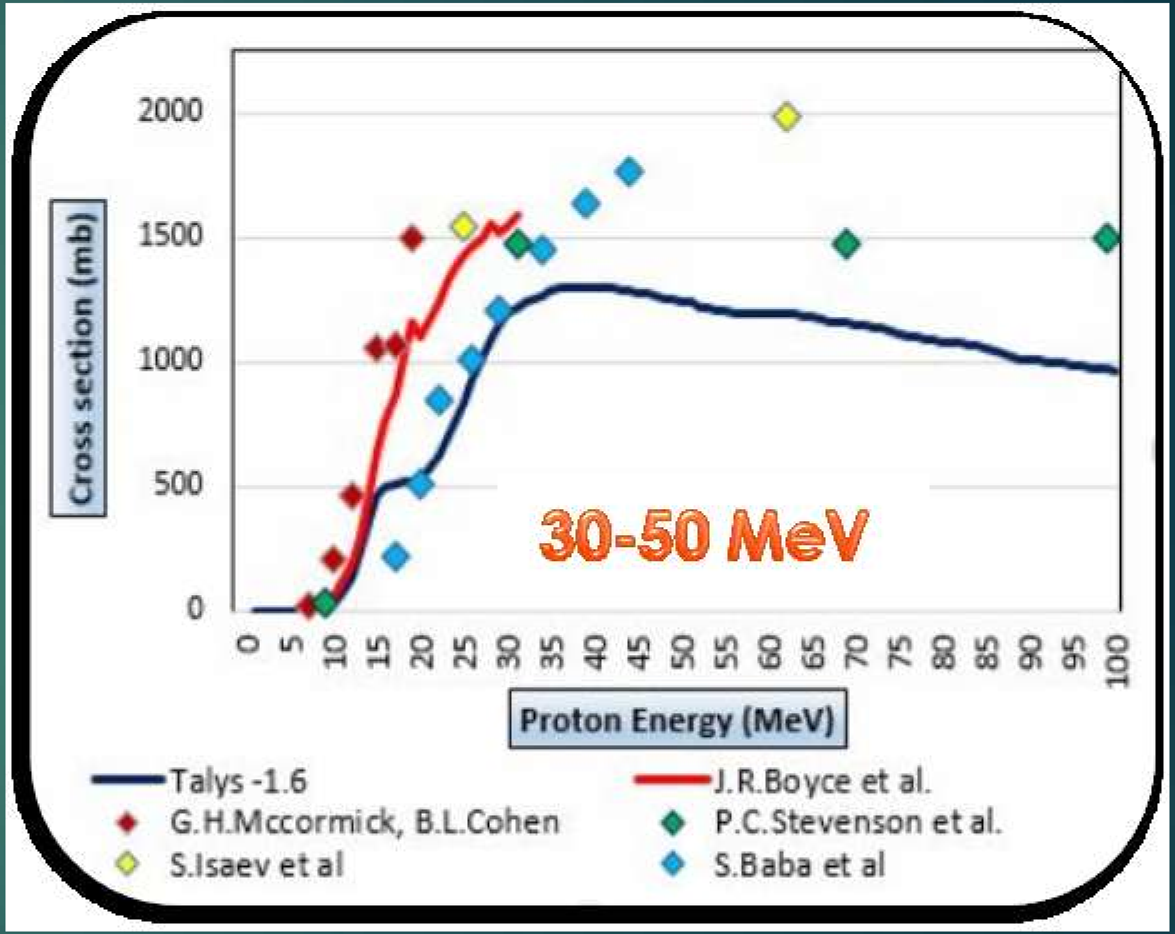
Composition of Nuclear Medical Procedures Where Technetium-99m is Predominant



PROTON-FISSION REACTION







P-fiss cross-sections on different fissionable materials

FIRST IDEA

ELSEVIER
Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms
Volume 278, 1 May 2012, Pages 20–25

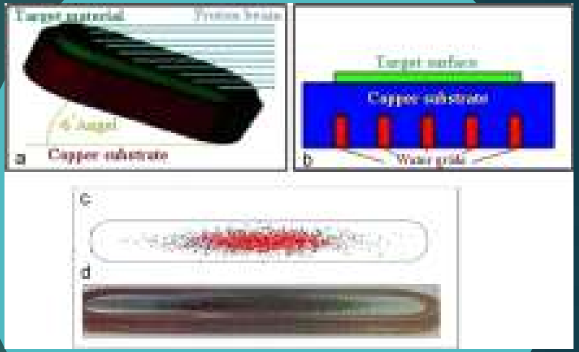
Feasibility of ^{99}Mo production by proton-induced fission of ^{232}Th

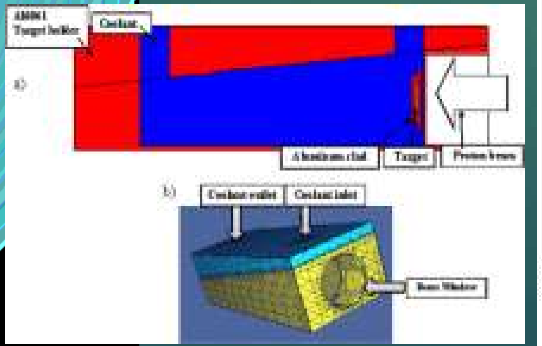
Kamel Abbas[a], Uwe Holzwarth[a], Federica Simonelli[a], Jan Kozempel[a], Izabela Cydzik[a], Antonio Bulgheroni[a], Giulio Cotogno[a], Christ…
Show more

ELSEVIER
Applied Radiation and Isotopes
Volume 101, July 2015, Pages 127–134

Computational investigation of ^{99}Mo production yield via proton irradiation of ^{nat}U and ^{232}Th targets

Seyed Mohammad Mirvakili, Masoumeh Alizadeh, Atyeh Joze… Davari





ELSEVIER
Applied Radiation and Isotopes
Volume 121, March 2017, Pages 64–70

Computational simulation of $^{nat}UO_2$, $^{232}ThO_2$ and U_3O_8-Al pills to estimate (p,fission) ^{99}Mo yield in the modeled targets irradiated by CYCLONE30 accelerator

Atieh Jozvaziri[a], Zohreh Gholamzadeh[a], Kamran Yousefi[b], Seyed Mohammad Mirvakili[a], Masoomeh Alizadeh[a], Mohammadreza Aboudzadeh[b]
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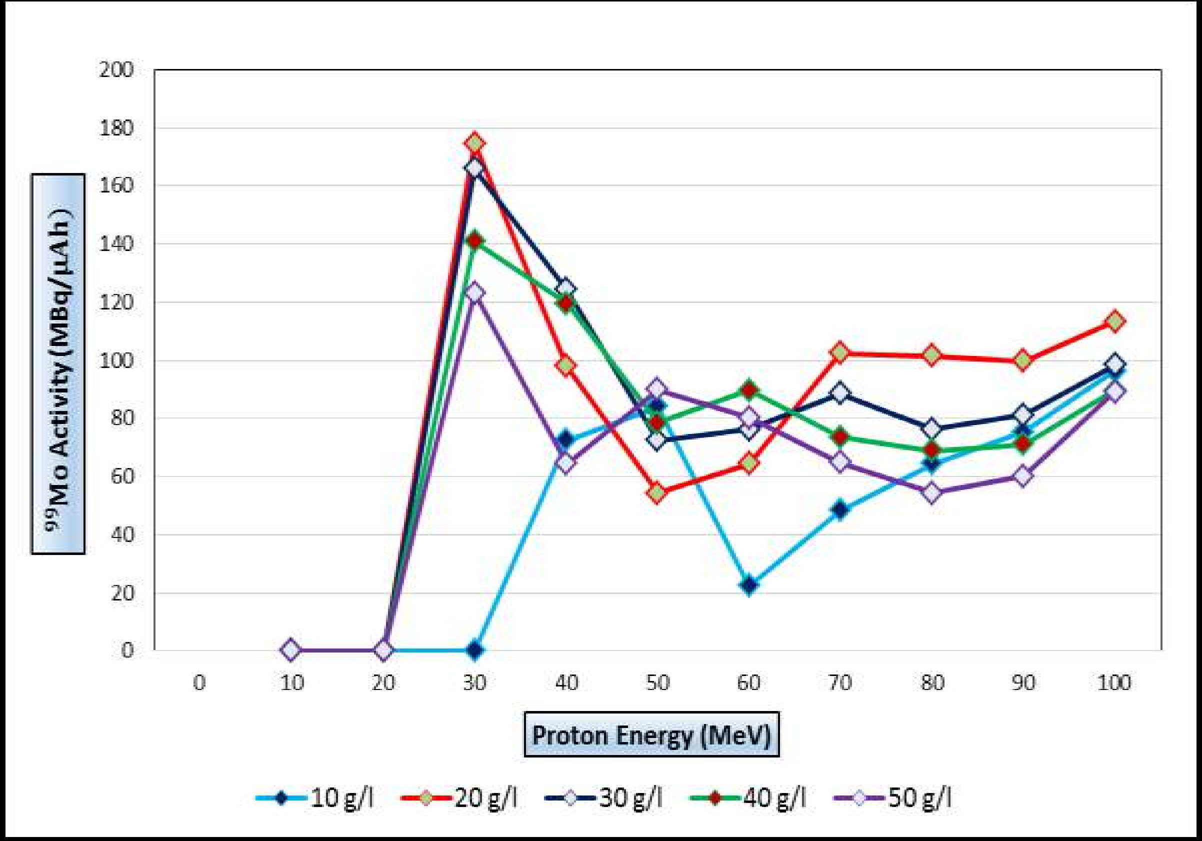
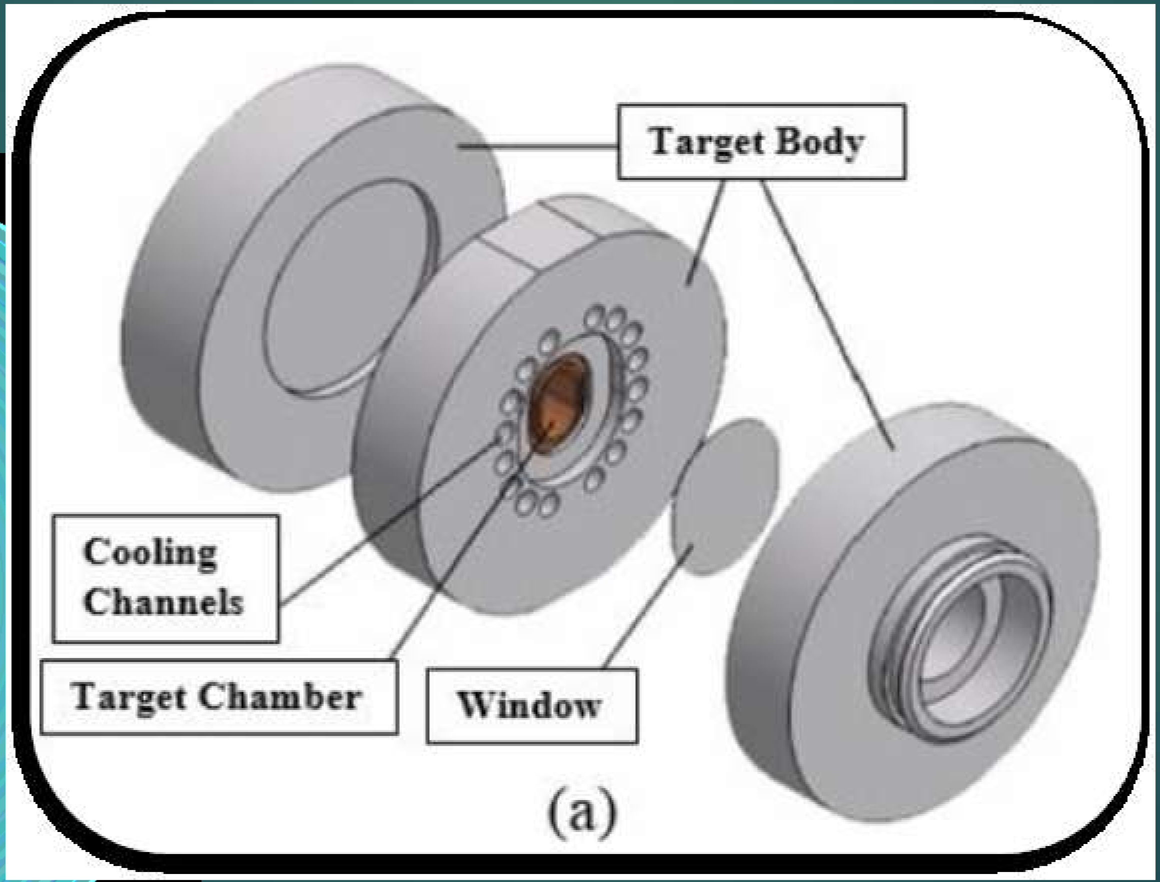
BATMAN EQUATION

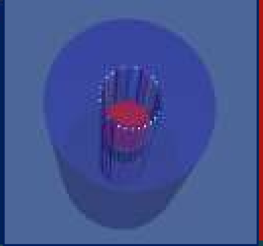
$$\frac{dN_i}{dt} = \sum_j \gamma_{ij}\,\sigma_{f,j}\,N_j\varphi + \sum_k \sigma_{c,k\to i}\,N_k\varphi + \sum_l \lambda_{l\to i}\,N_l - (\sigma_{f,i}N_{ji}\varphi + \sigma_{a,i}N_{ji}\varphi + \lambda_i\,N_l)$$



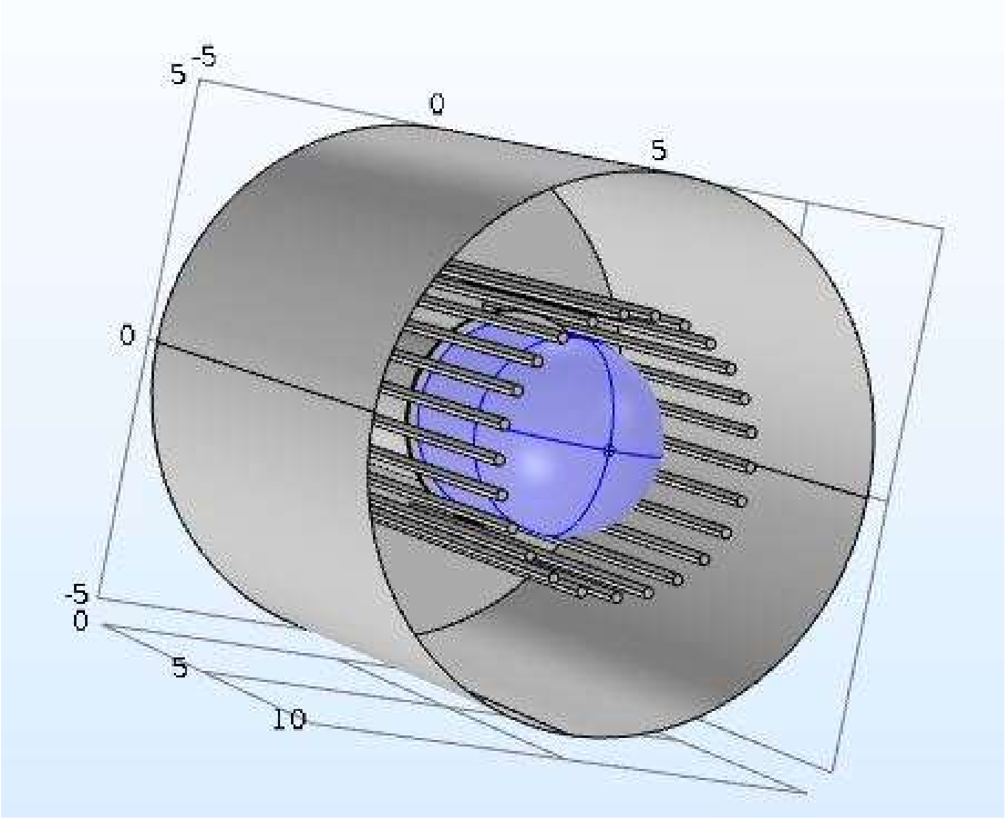
LIQUID TARGET MODELING



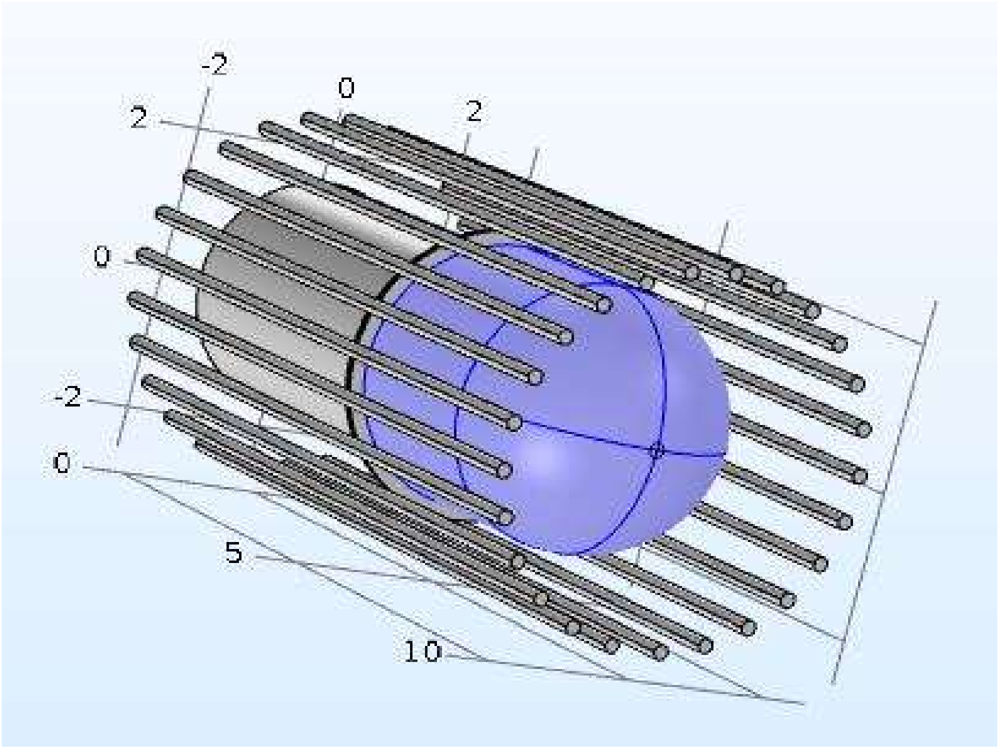
LIQUID TARGET SYSTEM FOR ^{99}Mo PRODUCTION



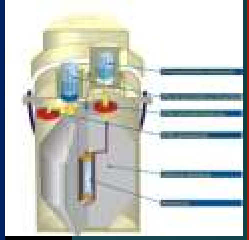
3D view of simulated liquid target



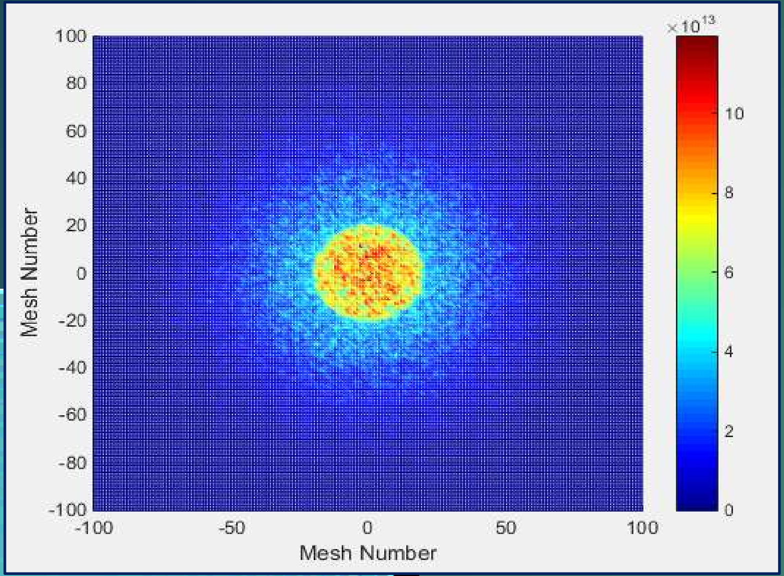
3D view of liquid target without container (Target holder)



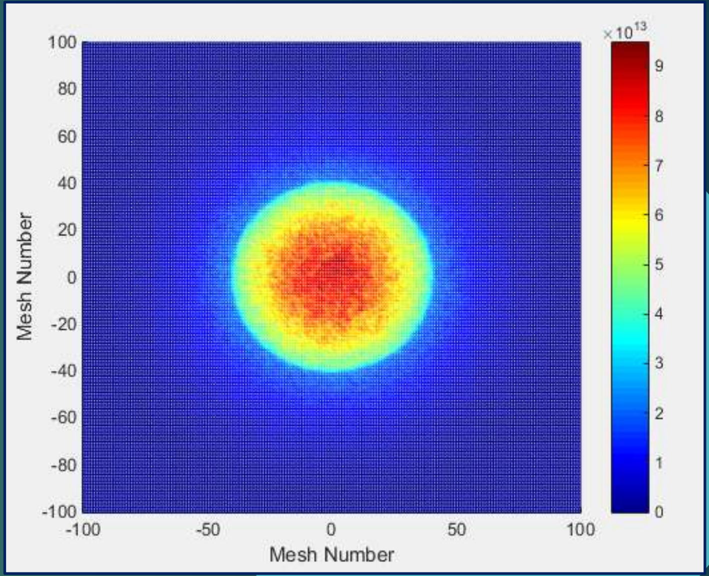
PROTON FLUX DISTRIBUTION INSIDE THE TARGETS WITH DIFFERENT RADII



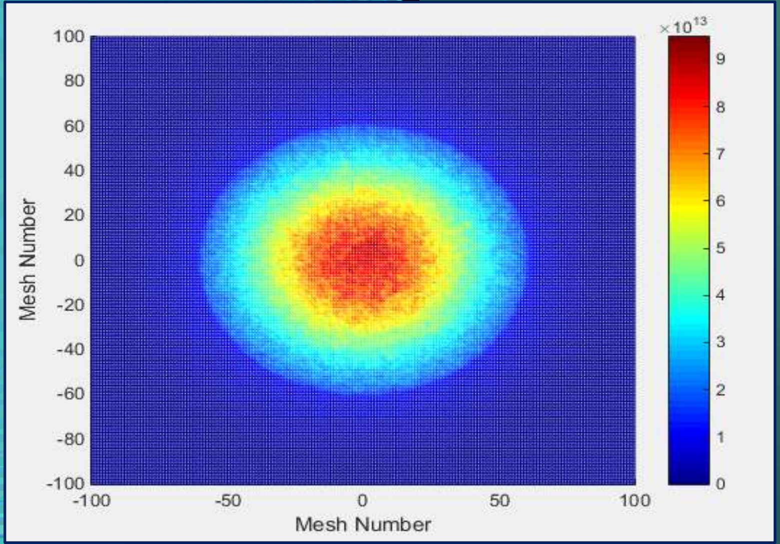
2 mm



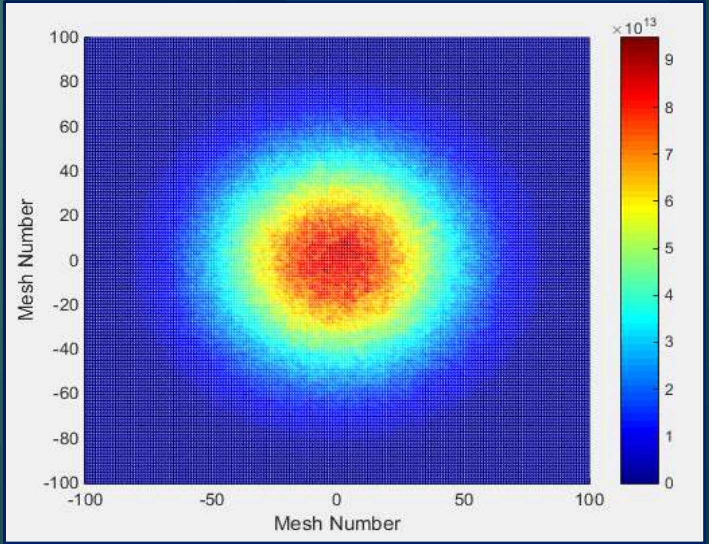
4 mm



6 mm

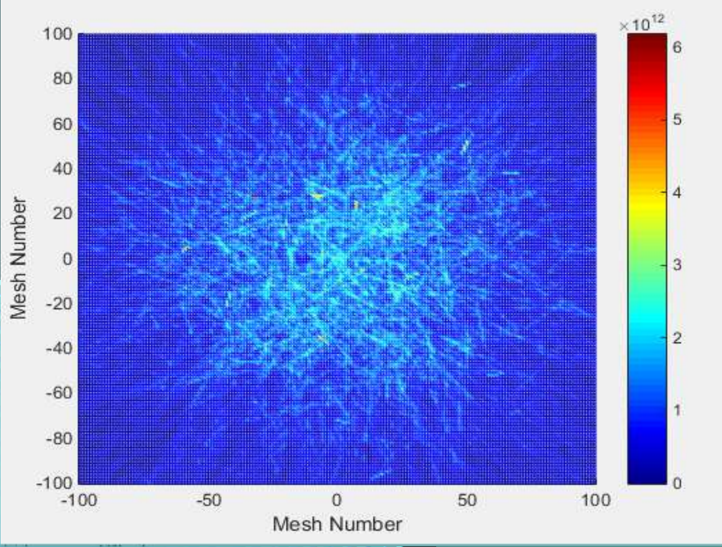


8 mm

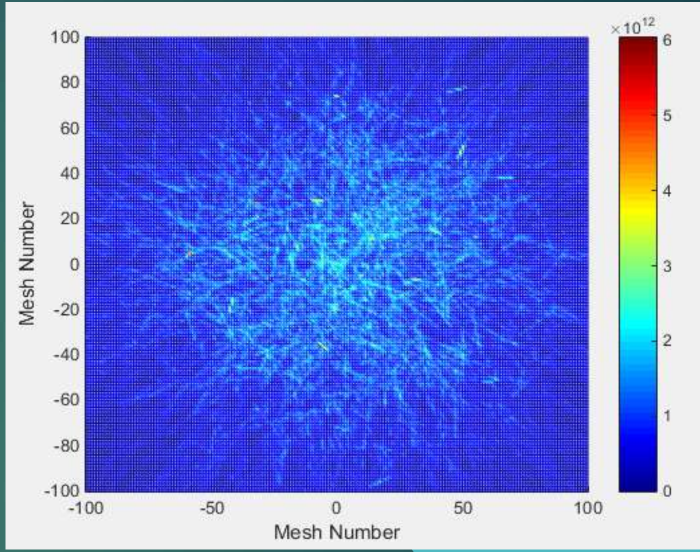


NEUTRON FLUX DISTRIBUTION INSIDE THE TARGETS WITH DIFFERENT RADII

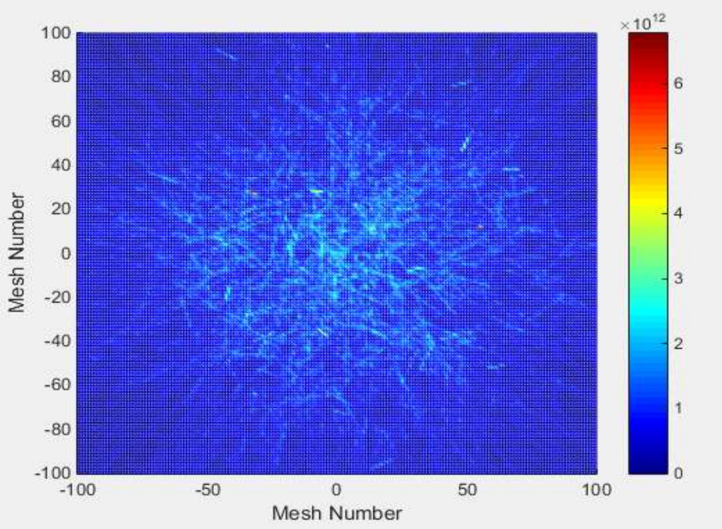
2 mm



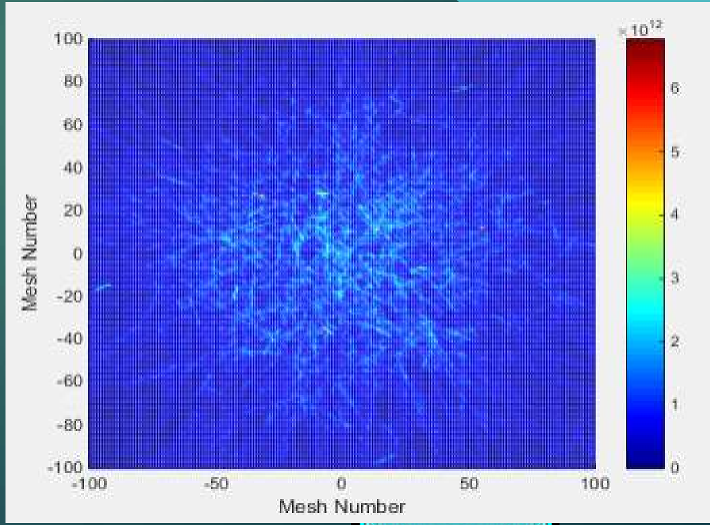
4 mm



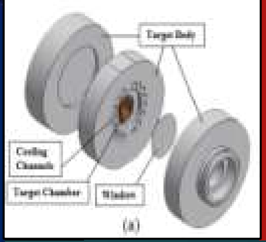
6 mm



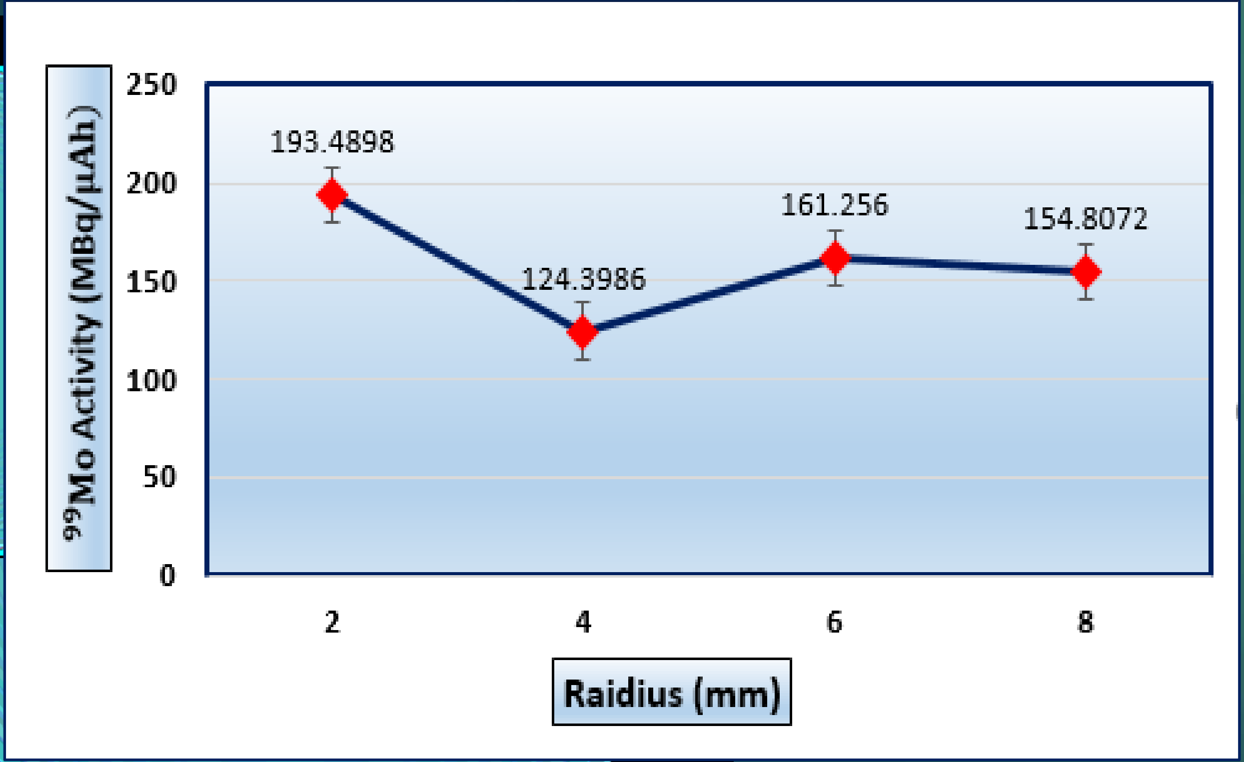
8 mm



RADIUS OPTIMIZATION FOR ^{99}Mo PRODUCTION



^{99}Mo Production depending on the radius of target in uranyl nitrate solution



For **24** Hours

193.48 MBq/µAh

By **150** μA

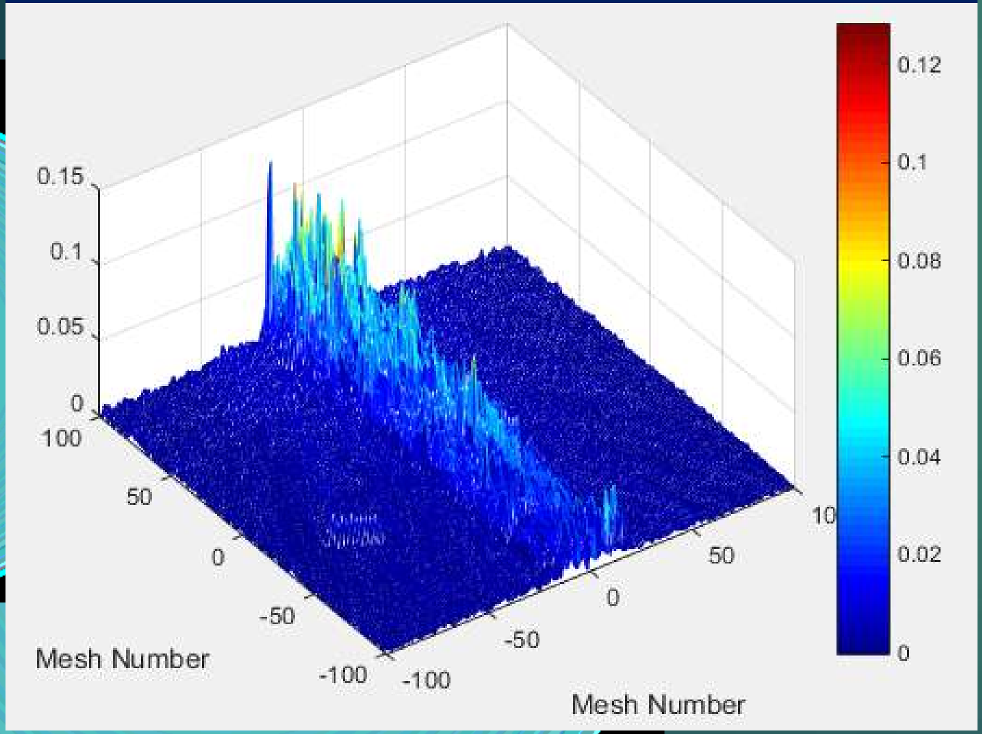
18.82 Ci

110 Ci/ $g_{nat_{UO_2(NO_3)_2}}$ ~ 975Ci/g-^{nat}U

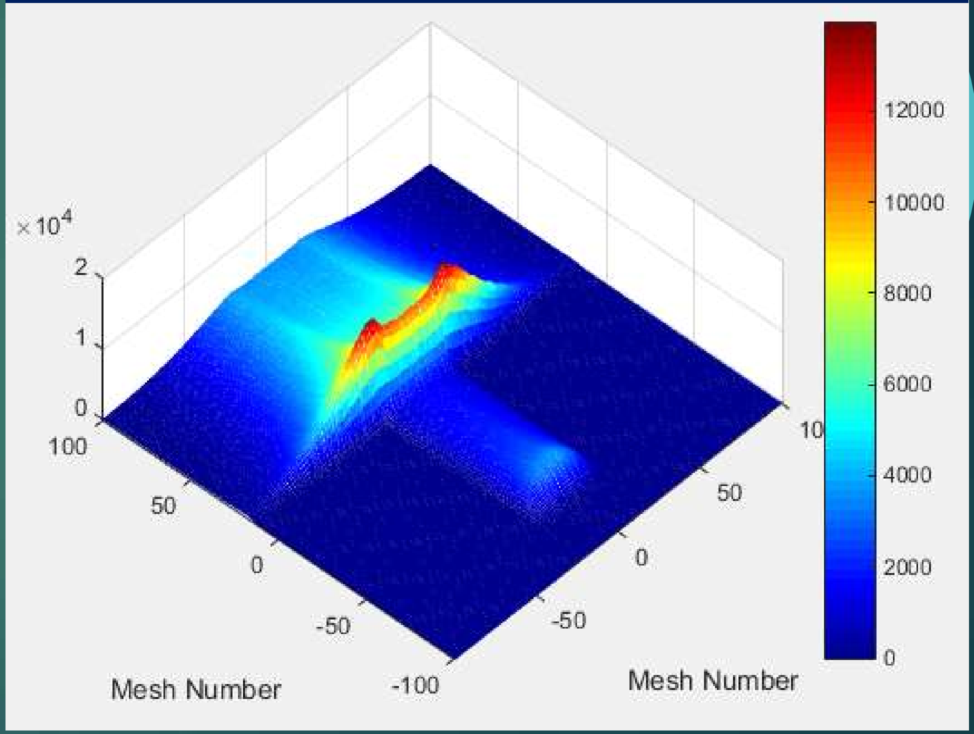
6.5 Ci/g-^{nat}U.µA

HEIGHT OPTIMIZATION FOR ^{99}Mo PRODUCTION

Neutron heat power deposited in solutions

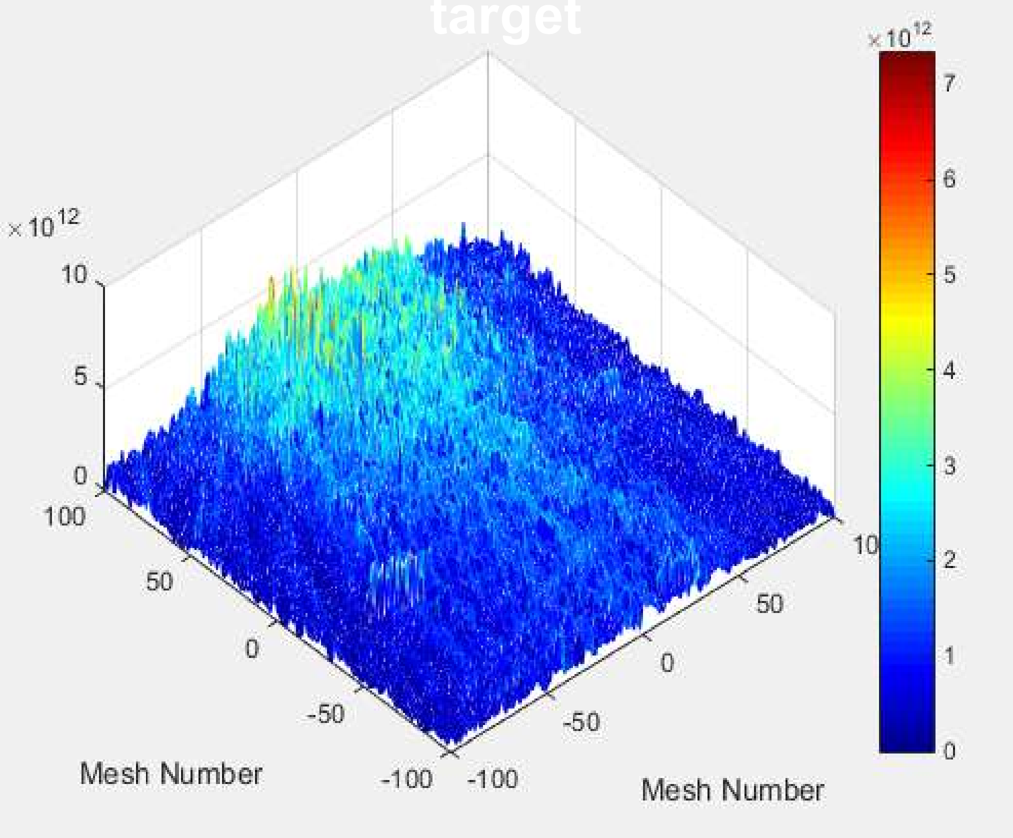


proton heat power deposited in solutions

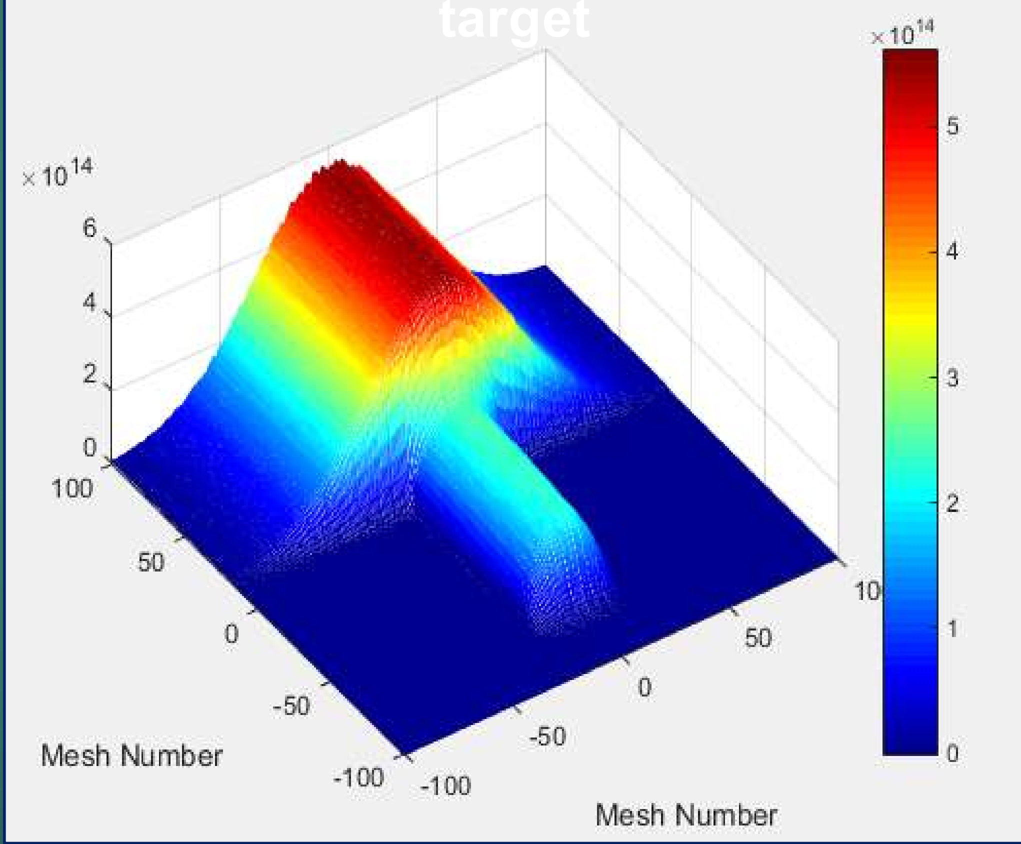


HEIGHT OPTIMIZATION FOR ^{99}Mo PRODUCTION

distribution of neutron flux in liquid target



distribution of proton flux in liquid target



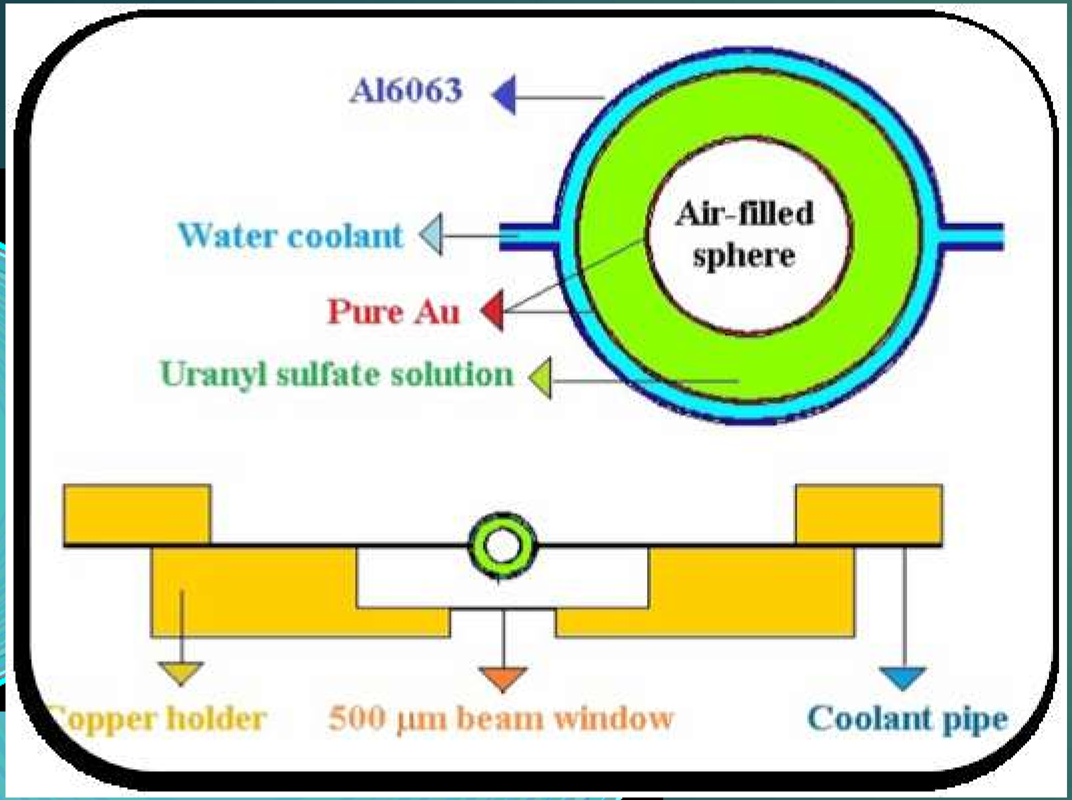
HEIGHT OPTIMIZATION FOR ^{99}Mo PRODUCTION

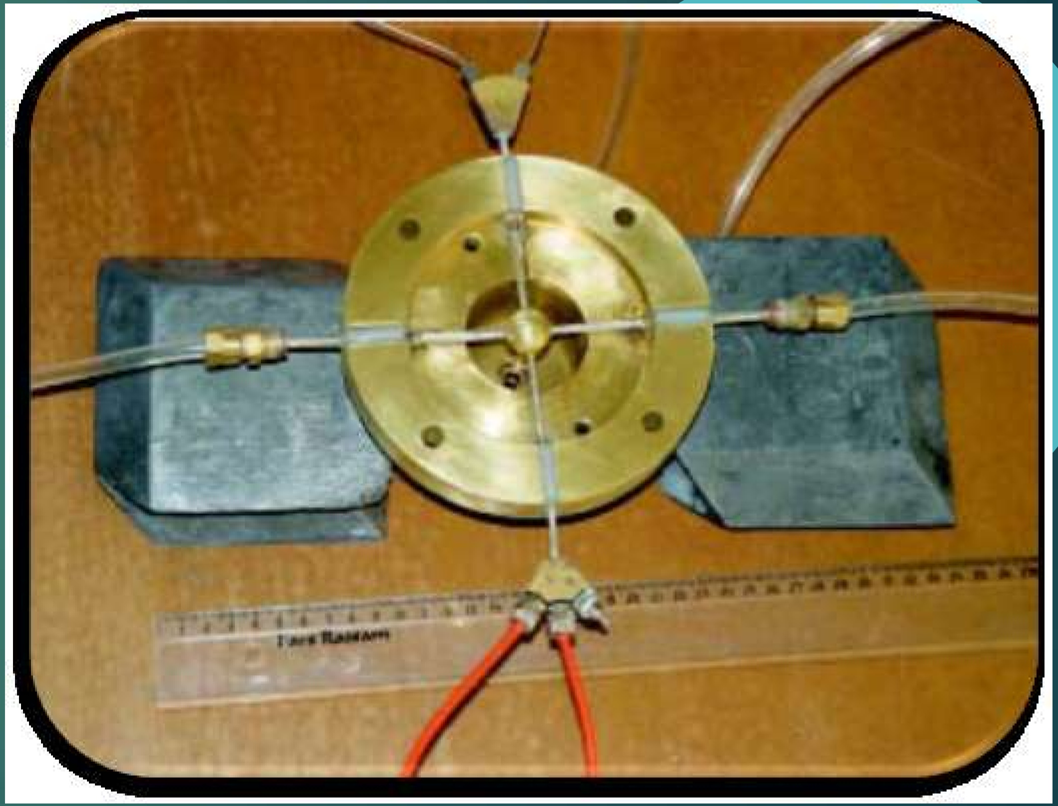
HEIGHT VARIATION → PRODUCTION OF ^{99}Mo IS CONSTANT → BECAUSE OF BETTER HEAT TRANSFER IN BIGGER TARGET AREA → WE CHOOSE A HEIGHT OF 20

Height (mm)	Neutron Flux (n/cm^2.s)	Proton Flux (p/cm^2.s)	Total Deposited Heat Power (W)	Neutron fission heat power (W)	Target Volume (cm^3)
8	1.84E+12	5.08E+14	5.37E+01	1.53E-04	1.17E-01
12	1.43E+12	[illegible]	[illegible]	1.69E-04	1.68E-01
16	1.17E+12	2.73E+14	9.98E+01	1.80E-04	2.18E-01
20	9.89E+11	2.22E+14	1.23E+02	1.86E-04	2.68E-01

2×8 mm

GOLD SPHERICAL CONTAINER FOR INVOLVING THE LIQUID TARGET





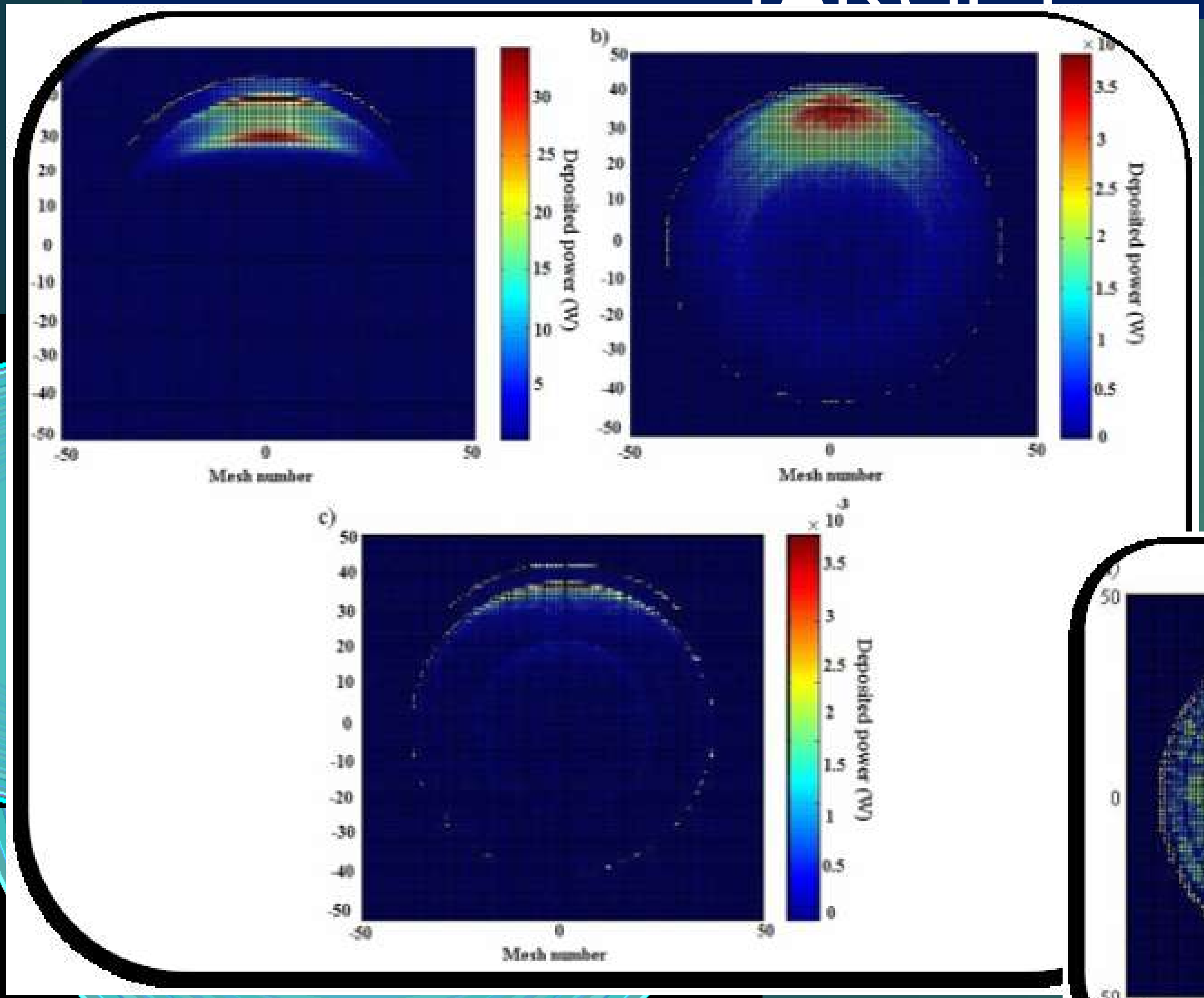
The purposed liquid uranyl sulfate container a) modeled by MCNPX2.6.0 Code b) used in the cyclotron accelerator

OUR RESULTS CONFORMITY WITH EXPERIMENTAL

Comparison of 99Mo production yield by different accelerator-based methods

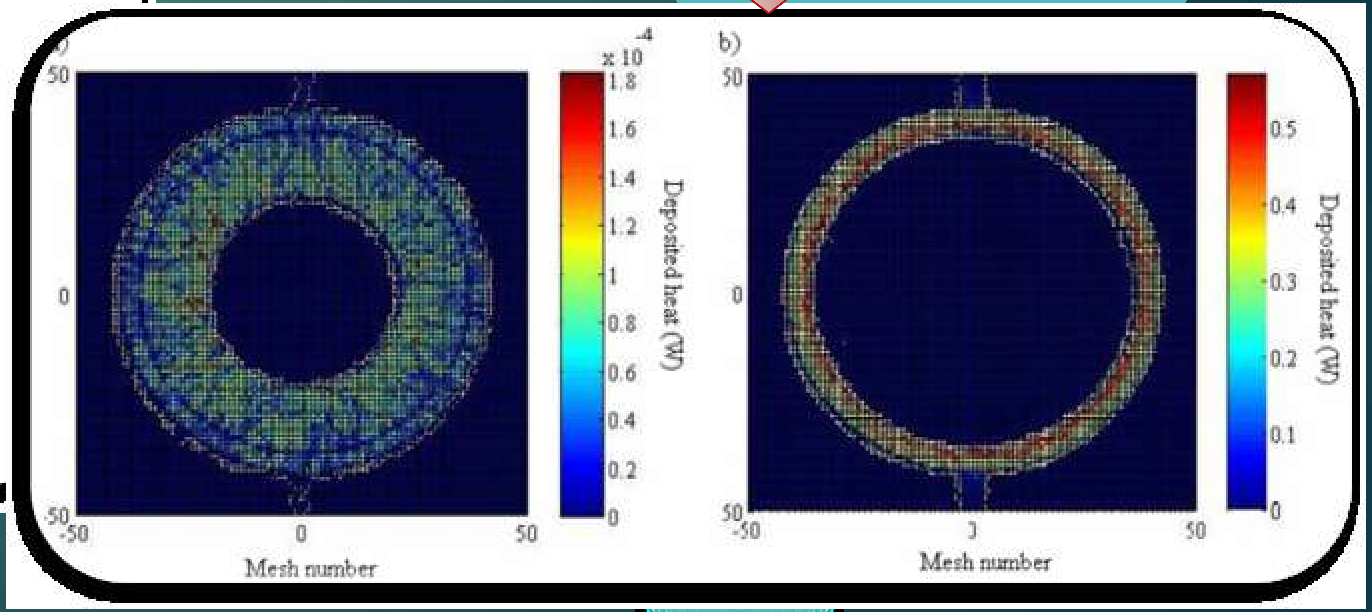
Reaction	Energy In (MeV)	Energy Out (MeV)	^{99Mo} yield (MBq/µA.h)	Ref.
^{100}Mo(p,x) ^{99}Mo	25	0	20.35	[15]
^{100}Mo(p,x) ^{99}Mo	25	0	26.64	[16]
^{100}Mo(p,x) ^{99}Mo	25	0	36.26	[17]
^{nat}Mo(p,x) ^{99}Mo	25	0	6.30	[18]
^{nat}Mo(p,x) ^{99}Mo	30	0	5.92	[19]
^{100}Mo(γ, n)^{99}Mo	–		3.029	[20]
^{nat}Mo(d,x)^{99}Mo	25	0	8.99	[21]
^{nat}Mo(d,x) ^{99}Mo	20	4	8.00	[2]
^{nat}Mo(d,x)^{99}Mo	22	0	8.28	[19]
^{232}Th(p, fiss)^{99}Mo	25	0	5.10	[2]
Solid target, ^{232}Th(p, fiss)^{99}Mo	25	0	4.93±0.29	[12]
Solid target, ^{nat}U(p, fiss)^{99}Mo	25	0	5.08±0.10	[12]
Liquid target, ^{nat}U(p, fiss)^{99}Mo	30	0	290.08±0.01	

DEPOSITED HEAT INSIDE THE TARGET



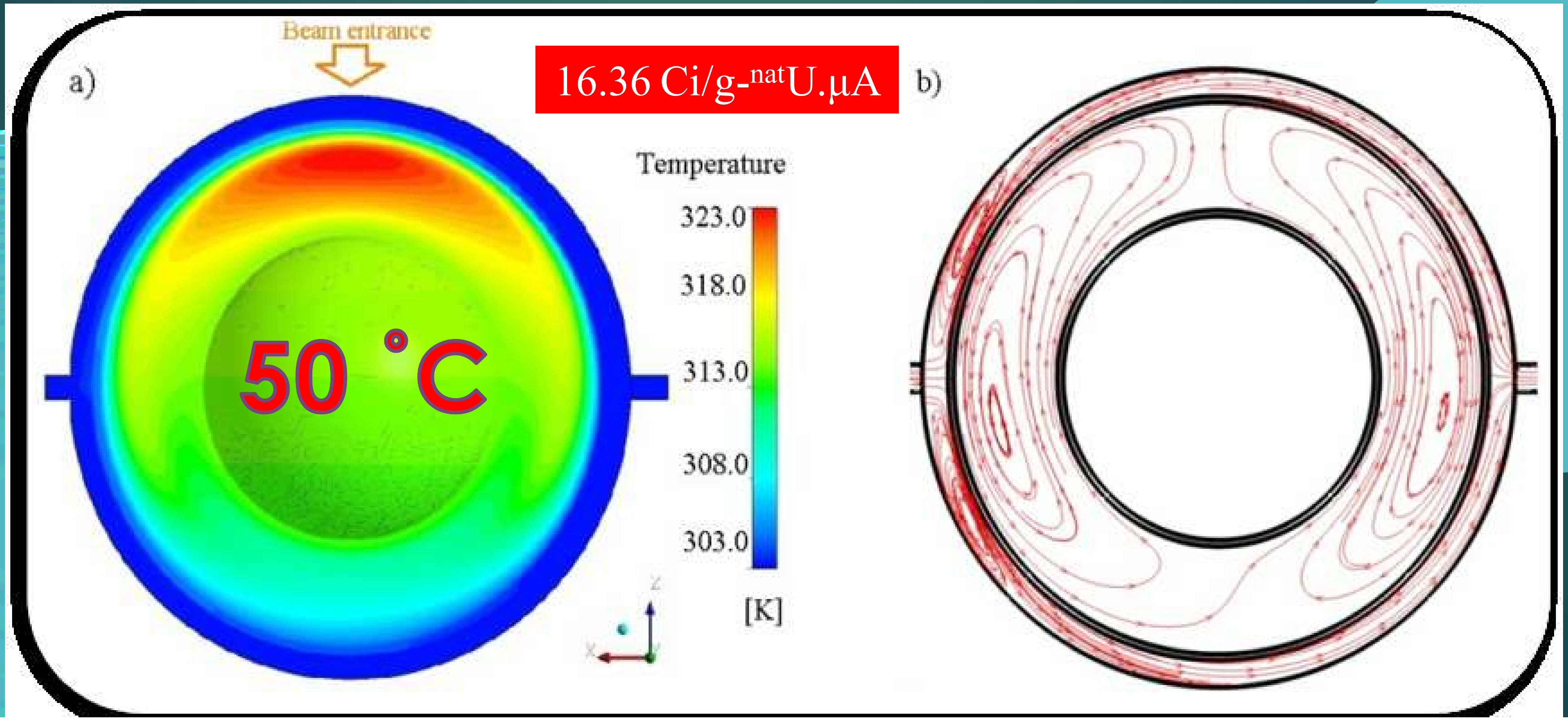
BEAM DIRECTION

VERTICAL TO BEAM



PEAK OF TEMPERATURE INSIDE THE TARGET

0.18 Ci after 24h irradiation using 1µA

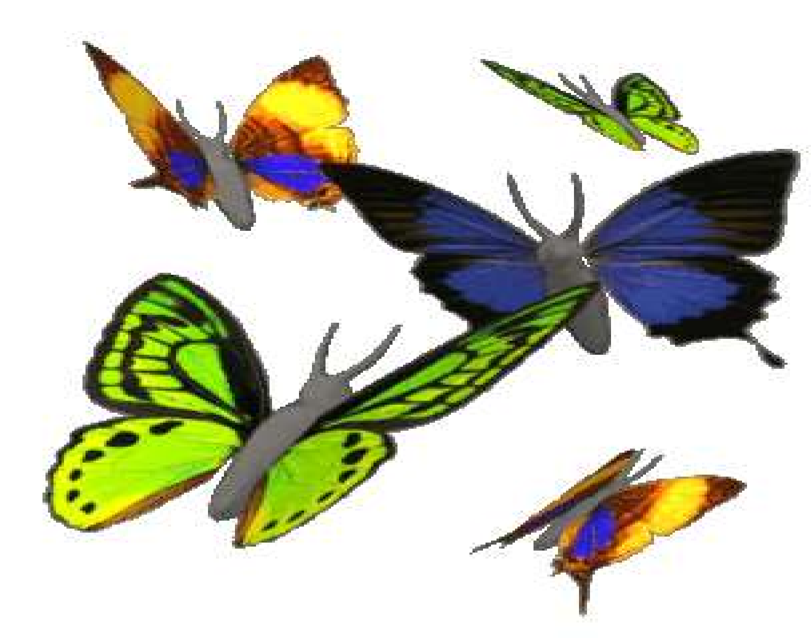


JET COOLING WITH FLOW RATE OF 25 M/S

A COMPARISON BETWEEN PRODUCTION METHODS

30 MeV, 4.5 kW, ~ 5 6-day-Ci/week , $^{Nat}U(p,fiss)^{99}Mo$

Particle	Accelerator	Reaction	Energy	Beam Power	Target	6-day-Ci/wk	kWh/6-day-Ci
Proton [3]	ADSR	$^{235}U(n,fission)^{99}Mo$	1 GeV	1 MW	LEU	~6000	~25
Proton [3]	ADSR	$^{98}Mo(n,\gamma)^{99}Mo$	1 GeV	1 MW	^{98}Mo	~3000	~50
Proton [4]	ADSR	$^{235}U(n,fission)^{99}Mo$	200 MeV	100 kW	LEU	~7000	~2.5
Electron[9]	RF Linac	$^{238}U(\gamma,fission)^{99}Mo$	50 MeV	1 MW	Natural U	~180	~900
Electron[9]	RF Linac	$^{100}Mo(\gamma,n)^{99}Mo$	>30 MeV	500 kW	^{100}Mo	~500	~170
Electron[10]	RF Linac	$^{100}Mo(\gamma,n)^{99}Mo$	25 MeV	20 kW	Natural Mo	~5	~800
Proton [6]	cyclotron	$^{100}Mo(p,pn)^{99}Mo$	45 MeV	4.5 kW	^{100}Mo	~2.5	~270
Proton [6]	cyclotron	$^{100}Mo(p,pn)^{99}Mo$	45 MeV	4.5 kW	Natural Mo	~0.25	~2700



IN MEMORY OF OUR NUCLEAR SC

Wishing you **love** and **peace**


thank you
for your