Fissile Actinides and α-emitters in High-Power Targets

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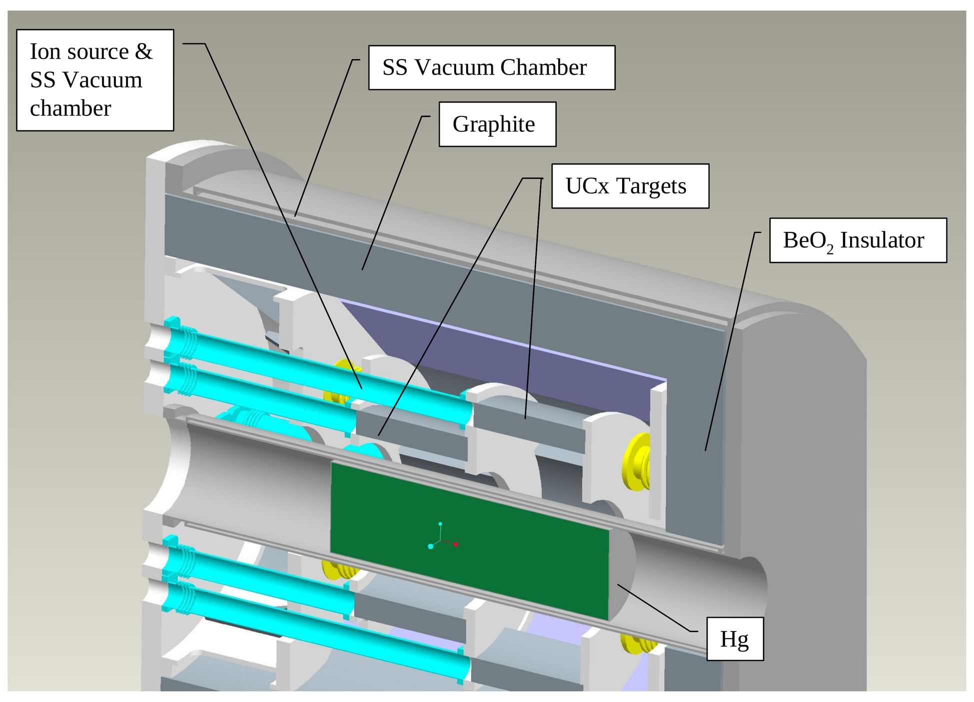
Two types of high-power actinide targets are proposed for EURISOL:

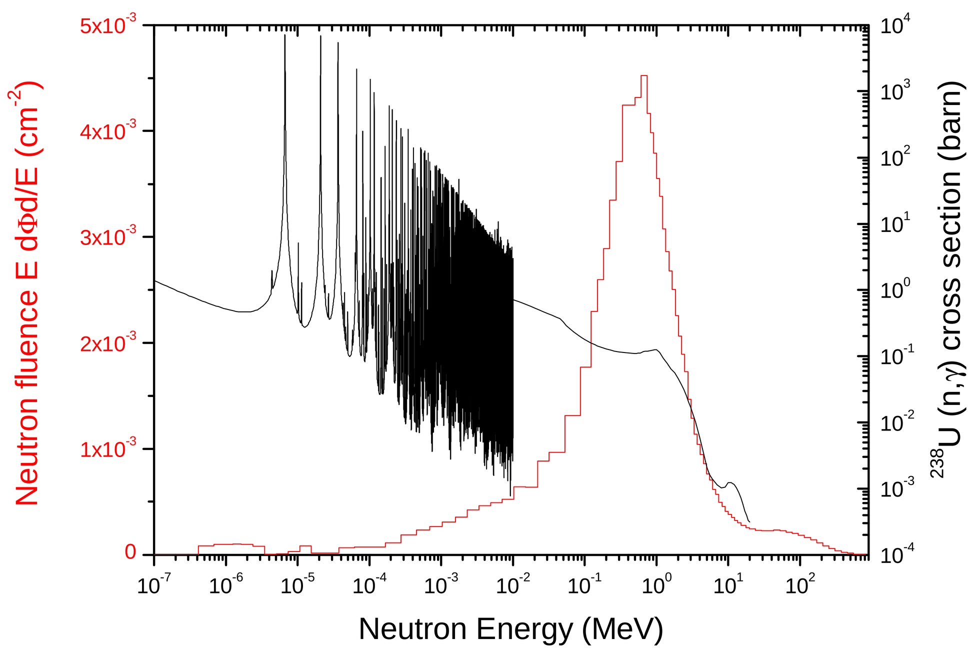
1. A "direct" target, in which a proton beam with a power of 100 kW hits the target material. Radionuclides are predominantly produced by spallation with fast projectiles (protons and secondaries)
2. A neutron spallation source with a fissile blanket material. The spallation source is driven by a 4 MW proton beam. Radionuclides are predominantly produced by fission with spallation neutrons.

Plutonium breeding in Multi-MW targets



Preliminary design of fission target. Overall dimensions 1m length by 1 m diameter. Length of the spallation source 50 cm, 30 kg of $^{238}UC_x$ in the blanket.

Fluence spectrum of spallation neutrons in $^{238}UC_x$ (red) and neutron capture cross section of ^{238}U. The product nuclide, ^{239}U, decays within an few days into ^{239}Pu, a fissile isotope



Target Type	Actinide used for target	Iron Shield	Z<92 products / proton	^{239}U/ proton	^{239}Pu for 3000h, 4 MW	
			atoms	atoms	atoms	mass (g)
U1	^{238}U	yes	0.32			
U2	U_{nat} (0.7 % ^{235}U)	yes	0.47	0.68	1.83 10^{23}	72.5
U3	U_{dep} (0.3 % ^{235}U)	yes	0.44			
ISOLDE for comparison	U_{dep} (0.3 % ^{235}U)	no	0.33	9.6 10^{-4}		

Monte-Carlo estimation (program FLUKA) of ^{239}Pu-production in a MMW ^{238}U-based fission target. The burn-up of ^{239}Pu in the target is small (< 1%). ^{232}Th as fissile material would lead to the production of ^{233}U, another fissile element

Results and Consequences

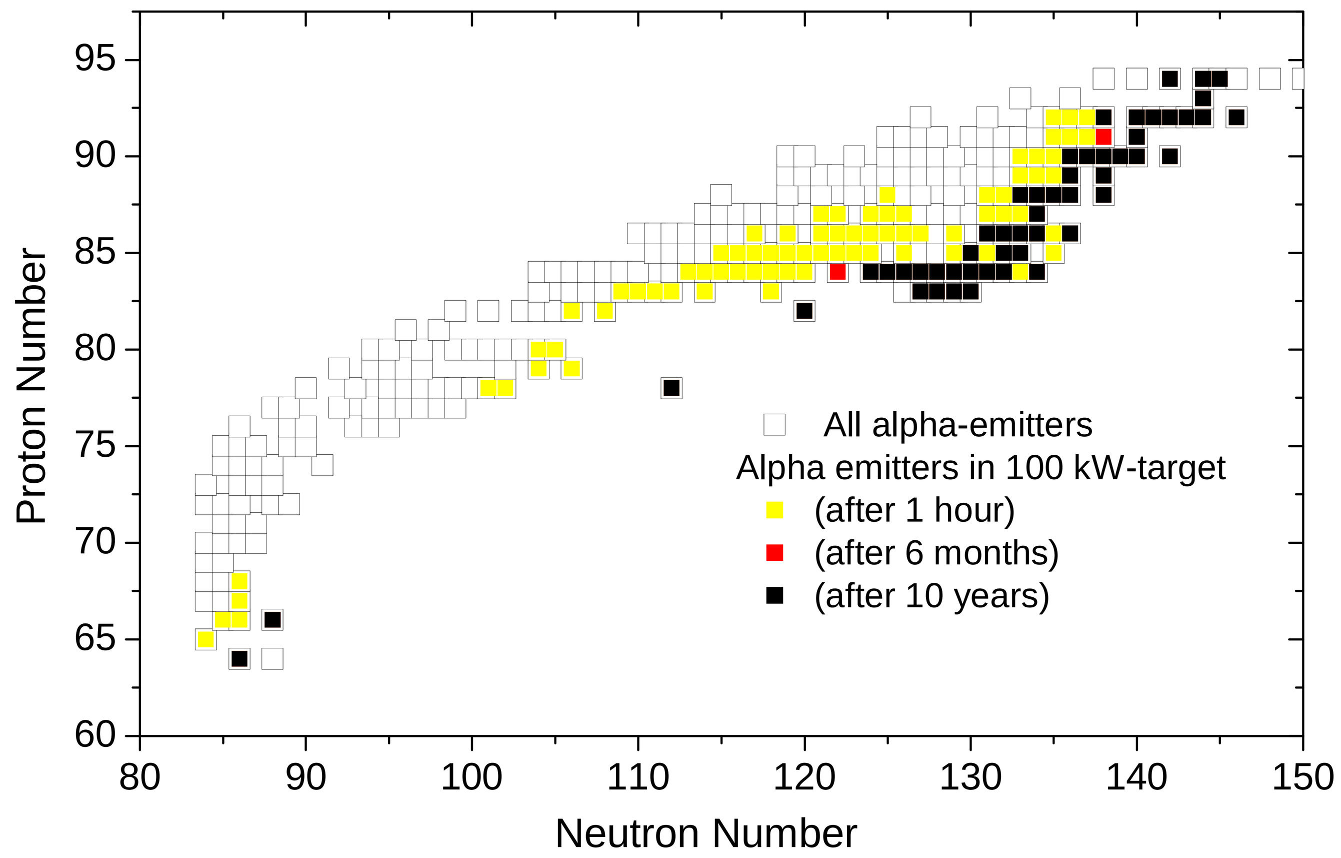
In a MMW fission target, more ^{239}Pu is produced than all other radionuclides taken together. The production efficiency (product nuclides per proton) is only marginally higher than for presently used ISOLDE targets.

The presence of fissile radionclide, chemically separable from the target matrix, requires safeguards against theft or sabotage, monitored by EURATOM or the International Atomic Energy Agency (IAEA)

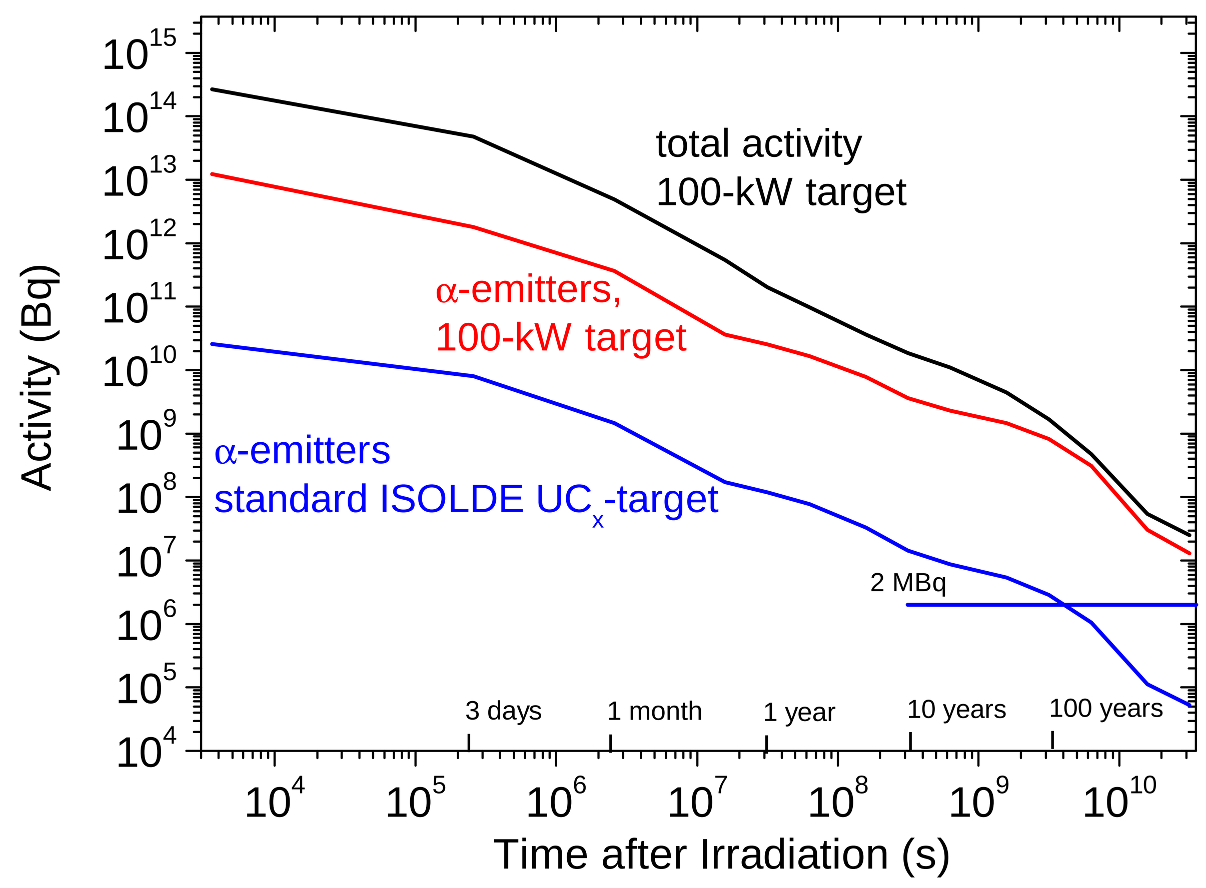
EURISOL will be run under the statutes of a "Nuclear Facility" (Switzerland) or a "Basic Nuclear Installation (INB)" in France.

Production of α-emitters in direct targets

Direct targets are basically an enlarged version of presently used ISOLDE targets. Here, the production of α-emitters in a 57 cm long $^{238}UC_x$ target (mass 8.8 kg) is calculated with the Monte-Carlo method (program FLUKA). It is assumed that the proton beam has the parameters
E = 1 GeV, *I* = 100 μA , *t* = 4.5 days



All α-emitters up to Pu (Z=94) (empty squares), and α-emitters present in a EURISOL target after specified waiting time (coloured squares)



Time evolution of total activity and α-activity contained in one UC_x target

Results and Consequences

The significant amount and radiotoxicity of α-emitters produced in a 100-kW UC_x target requires complete encapsulation and automatic handling of spent targets, from the separator over intermediate storage, conditioning and long-term waste storage.

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