TOMSK
POLYTECHNIC
UNIVERSITY

Prospects for the use of activation of molybdenum for the production of technetium-99m generators

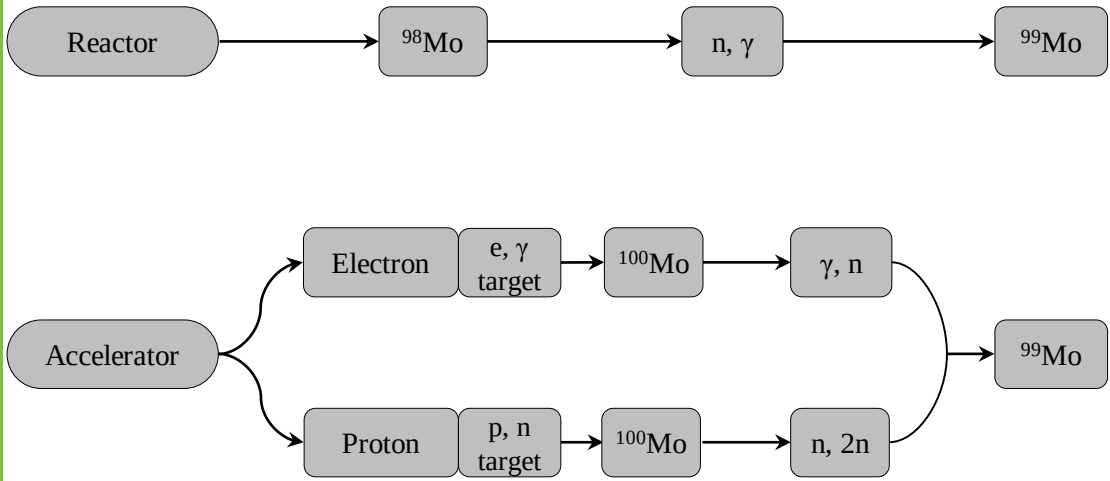
Viktor Skuridin
Head of the Lab №31
Research Nuclear Reactor IRT-T
Tomsk, Russia

Vienna-2017

Disadvantages of $^{235}U(n,f)^{99}Mo$ method

- Lots of waste (more than 20 long-living nuclides including α-emitting ^{239}Pu), that require reprocessing and storing
- Integral activity is 10 times higher than the activity of the product
- Long period of reprocessing of the target and substraction of ^{99}Mo – more than 2 days
- Necessity of regeneration ^{235}U and returning it to technological cycle

Production of Mo-99 from enriched Molybdenium



Disadvantages of activation molybdenium production

- Low specific activity of produced ^{99}Mo in spite of big mass of enriched, expensive target

- Large content of inactive Molybdenium “carrier”, which requires the use of chromatographic columns with increased sizes

- Consequence – low specific activity and big size of generator

Radiation capture $^{98}Mo(n,\gamma)^{99}Mo$

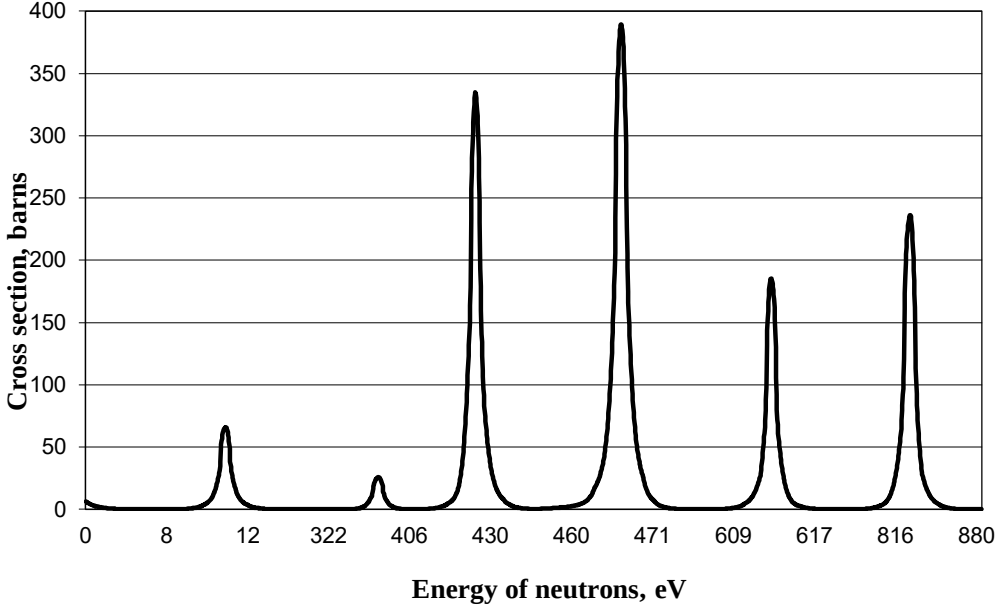
- σ=0,136 barns on thermal neutrons
- Even with > 95 % enrichment of tergets in a flux **$1 \cdot 10^{14}$ $n/cm^2 \cdot s$** activity will not exceed 5,47 Ci/g;
- Flux **$5 \cdot 10^{15}$ $n/cm^2 \cdot s$** can provide 200 Ci/g ;

In a common case effective cross section is defined as

$$\sigma^* = \sigma + \xi\gamma I,$$

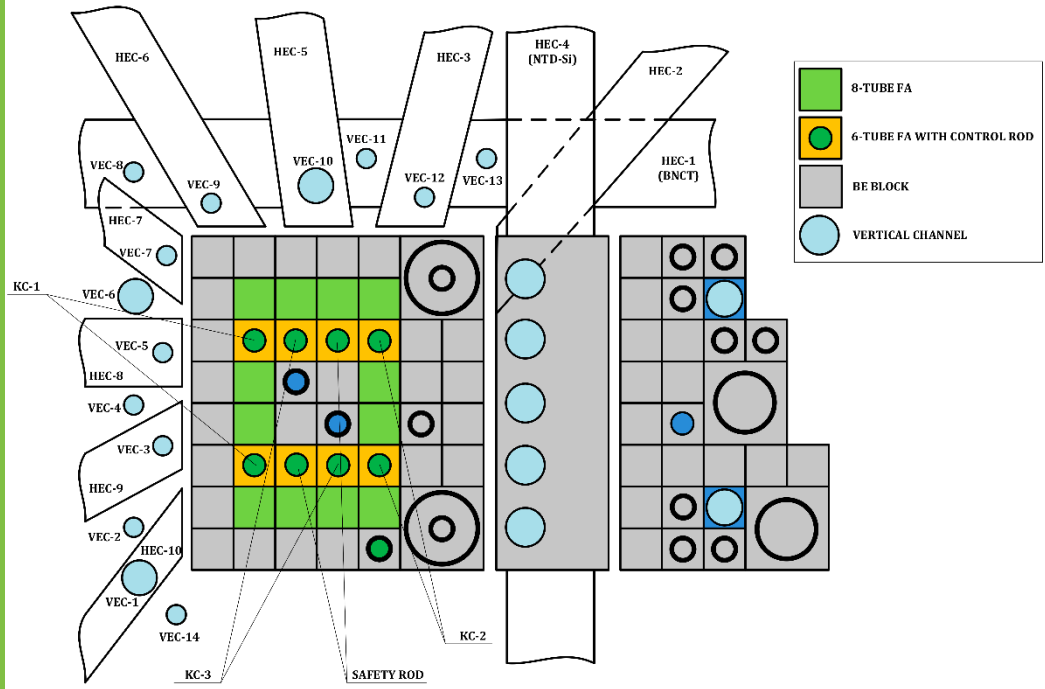
whereas σ = 0,136 barns and I = 6,9 barns, ξ- block coefficient, γ - hardness of the spectrum.

Dependence of cross section $^{98}Mo(n,\gamma)^{99}Mo$ on energy of neutrons



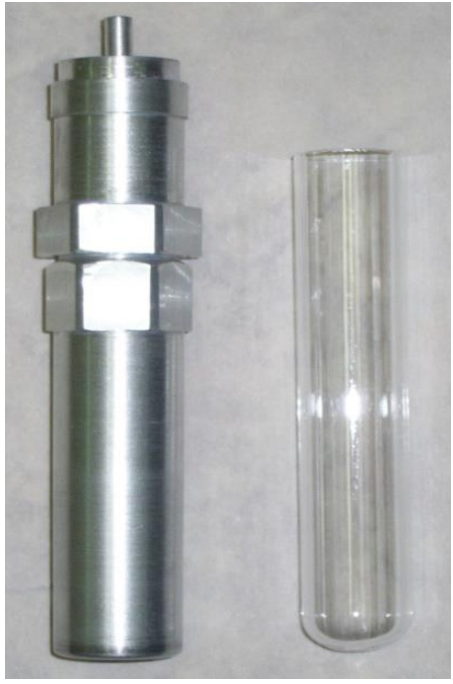
Research reactor IRT-T of Tomsk Polytechnic University

Scheme of IRT-T reactor core



Generator of Technetium «^{99m}Tc-GT-TOM»

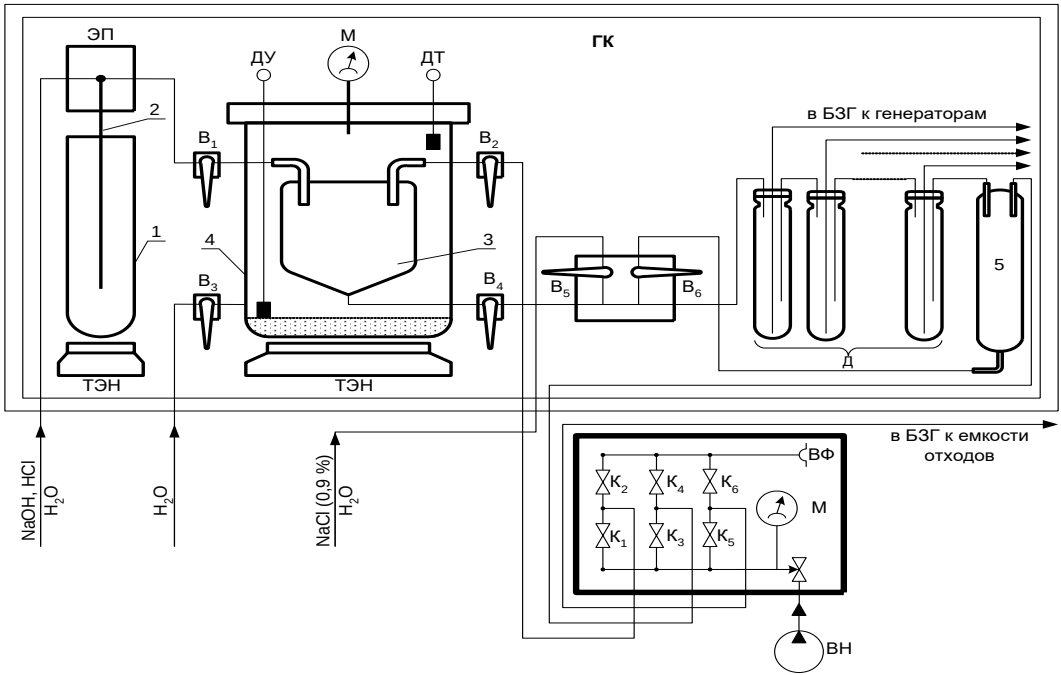
Construction of targets for irradiation of MoO_3



Target dissolution device

Generators refueling control room

Generators refueling scheme



Chromatographic columns

Regeneration of Molybdenium-98 and reprocessing of the waste

- Efficiency of subtracting Mo out of columns is **96,5 %**
- Out of liquids - **99 %**
- Overall losses < **8 %**
- In a 5 years of production 100 g of MoO_3 was used

General level of radioactive waste (ampoules, penals, sorbent) in relation to produced activity of ^{99}Mo doesn't exceed $\mathbf{1 \cdot 10^{-4}}$ **%**, which is several orders less than when HEU and LEU targets are used.

Assessment of possibility of activation ^{99}Mo for regional production

- 100 gamma-cameras – 50 Ci/g ^{99}Mo
- 98,6 % enrichment Mo-98 on SM-3
- 1 generator with 18,5 GBq 0,025 g Mo needed
- 100 generators a week – 2,5 g of Mo target, 4,2 g of oxide - $525

Conclusions

- Reached effective cross section 0,7 barns was reached in IRT-T reactor. This is not a limit.
- Additional investigation on optimization of reflector geometry is needed to increase activity up to 50 Ci/g and more.
- Technology is relatively cheap since it is wasteless and doesn’t require additional purification facilities.
- In frames of joint project with the support of IAEA TPU is ready to develop regional production unit in several years.