Study on Usage of Low Enriched Uranium Russian Type Fuel Elements for Design of an Experimental ADS Research Reactor

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SUMMARY

Conceptual design of an **a**ccelerator **d**riven **s**ub-critical experimental **r**esearch **r**eactor (ADSRR) was initiated in 1999 at the Vinča Institute of Nuclear Sciences, Serbia and Montenegro. Initial results of neutronic analyses of the proposed ADSRR-H were carried out by Monte Carlo based codes and available **h**igh-**e**nriched **u**ranium dioxide (HEU) dispersed Russian type TVR-S fuel elements (FE) placed in a lead matrix. Beam of charged particles (proton or deuteron) would be extracted from the high-energy channel H5B of the VINCY cyclotron of the TESLA Accelerator Installation. In 2002, the Vinča Institute has, in compliance with the **R**educed **E**nrichment for **R**esearch and **T**est **R**eactors (RERTR) Program, returned fresh HEU TVR-S type FEs back to the Russian Federation. Since usage of HEU FEs in research reactors is not further recommended, a new study of an ADSRR-L conceptual design has initiated in Vinča Institute in last two years, based on assumed availability of **l**ow-**e**nriched **u**ranium (LEU) dispersed type TVR-S FEs. Initial results of numerical simulations of this new ADSRR-L, published for the first time in this paper, shows that such a small low neutron flux system can be used as an experimental - "demonstration"- ADS with neutron characteristics similar to proposed well-known lead moderated and cooled power sub-critical ADS with intermediate neutron spectrum. Neutron spectrum characteristics of the ADSRR-L are compared to ones of the ADSRR-H with the same mass (7.7 g) of ^{235}U nuclide per TVR-S FE.

Designed parameters of the VINCY cyclotron of the TESLA accelerator are set more than 15 years ago and are not favourable in respect to drive an ADS for energy production or transmutation of trans-uranium nuclides. The cyclotron can deliver either protons with maximum energy of 75 MeV and current of 5 μA, or deuterons with maximum energy of 73 MeV and current of 50 μA. Thus, a spallation neutron source is not available and one of the main tasks in the ADSRR project will be study of interaction of the beam particles with different target materials in order to choose and design an optimal target in respect to escaping neutron spectrum and neutron yield.

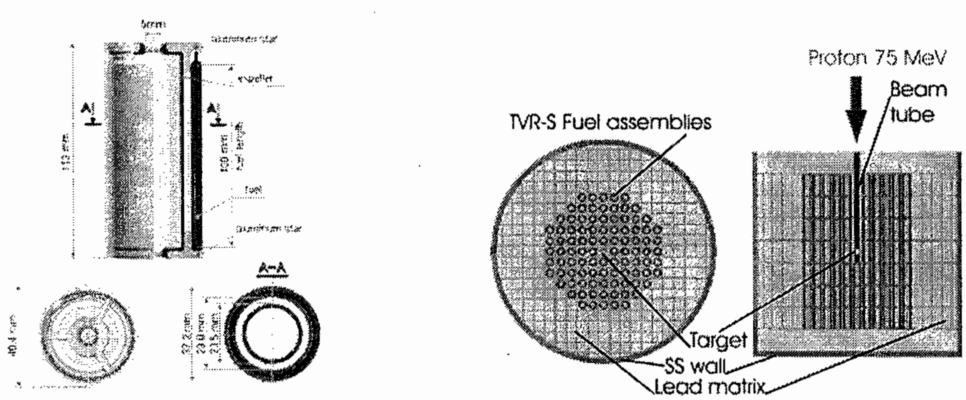

Figure 1. Sketch of TVR-S type fuel slug and ADSRR-L

Neutron yield and neutron spectra from different target materials are calculated for various energies (10 MeV - 75 MeV) of an incident beam of protons or deuterons using well-known Monte Carlo codes: SHIELD from Russia, and LCS and MCNPX from USA. Criticality and neutron spatial-energy distributions are calculated using MCNPX2.4.0 and MCNP5 codes.

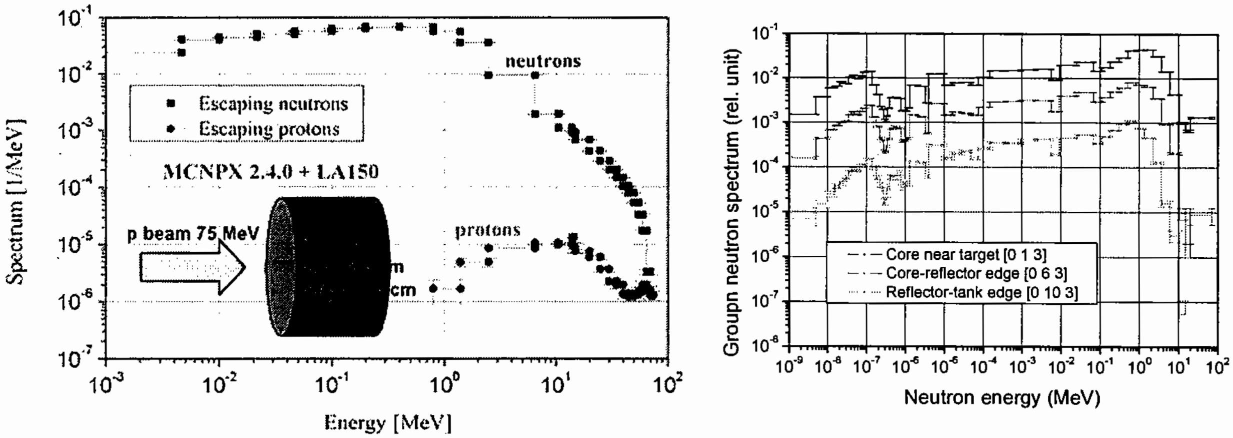

Figure 2. Spectrum of escaping neutrons and protons from Pb target and neutron spatial-energy distribution in the ADSRR-L

Table 1. Values for k_{eff} and l_p in ADSRR

ADSRR-H				ADSRR-L			
No. TVR-S slugs/FA	Axial Pb reflector [mm]	$k_{eff} \pm 1\sigma$	$lp \pm 1\sigma$ [μ s]	No. TVR-S slugs/FA	Axial Pb reflector [mm]	$k_{eff} \pm 1\sigma$	$lp \pm 1\sigma$ [μ s]
6	113	0.9709 ± 0.0006	84.9 ± 0.1	6	2 x 113	0.9677 ± 0.0003	88.6 ± 0.1
6	2 x 113	0.9865 ± 0.0006	91.5 ± 0.1	7	113	0.9760 ± 0.0003	82.8 ± 0.1

The basic aim of the proposed ADSRR-L project is to study the physics and development of the technologies necessary to design a small sub-critical low neutron flux research reactor (with LEU TVR-S FE) driven by an accelerator medium energy proton beam. The reactor could be used for basic and applied research in neutron physics, metrology, dosimetry and radiation protection, in radiobiology and for development of modern nuclear technologies. Initial results of the neutronic study have shown that it is possible to design a low neutron flux ADSRR with dominant fast neutron spectrum using fresh LEU FEs and light water as primary moderator in lead matrix. That system is driven by a neutron source generated in a lead target by interaction of proton beam, extracted from the TESLA Accelerator Installation.

Basic References

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