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Accelerator Driven Subcritical Research Facility H5B Calculation.

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ABSTRACT

The H5B is a concept of accelerator driven subcritical research (ADSR) facility developed at the Vinca Institute of Nuclear Sciences, Belgrade, the Republic of Serbia. The neutron source is generated by interaction of proton or deuteron beam with a target placed inside of the subcritical core. Neutron yield, Neutrons spectra, integral parameter, flux distribution, keff, neutron generation time were evaluated in this work.

1. INTRODUCTION

The Accelerator Driven System is an innovative reactor which is being considered as a dedicated High Level Waste Burner in a double strata fuel cycle. The "status of the art" of the R&D in ADS has been intensively reported in the literature [1, 2]. In short an ADS consist of a particle beam from an accelerator inducing nuclear reactions in a target to produce secondary neutrons which are the external source in a sub critical core. Therefore the target is the physical and functional interface between the accelerator and the sub-critical reactor. For this reason it is probably the most innovative component of the ADS. The target design is a key issue to investigate in designing ADS and its performances are characterized by the number of neutrons emitted per incident proton, the mean energy deposited in the target for neutron produced, the neutron spectrum and the spallation product distribution.

The H5B is a concept of accelerator driven subcritical research facility developed at the Vinca Institute of Nuclear Sciences, Belgrade, the Republic of Serbia[4].

This paper will report some preliminary results for targets and core, such as those proposed in the collaborative work on the Low Enriched Uranium Fuel Utilization in ADS for Serbia H5B Accelerator Sub Critical Research, the simulations were performed with MCNPX 2.5 [3].

2. FACILITY SPECIFICATION AND RESULTS

H5B uses Russian origin low enriched uranium fuel of TVR-S type placed in a lead matrix. The neutron source is generated by interaction of proton or deuteron beam, extracted from TESLA accelerator, with a target placed inside of the subcritical core (see Figure 1).

Core section is assembled using 109 fuel assemblies arranged within regular 11 x 11 matrix in the central part of the tank. The pitch of this square lattice is 50 mm. Central Fuel assembly is coaxial with the tank axis. Total number of LEU TVR-S Fuel elements used for the core design is 759 (see Figure 1). The fuel element was modelled using the aproximations proposed in the benchmark specification.

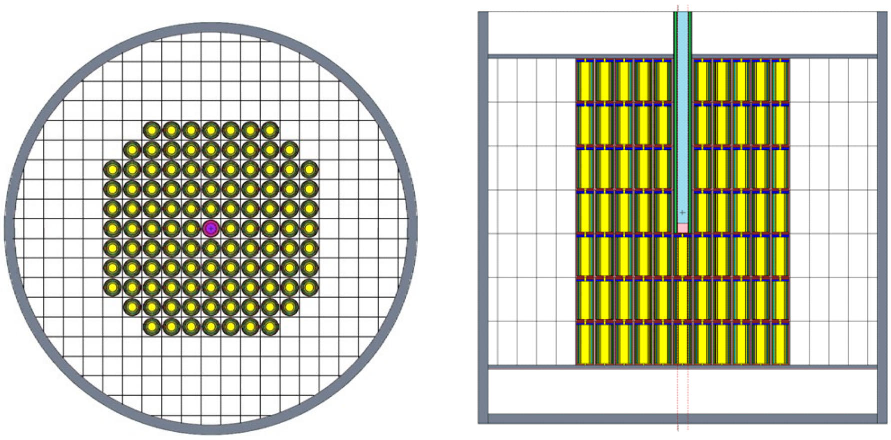

Figure 1. Horizontal and vertical cross section of the model of LEU ADSRF (H5b) core at the target level.

2.1. SOURCE RESULTS

To simulate an ADS neutron source one needs to know the parameters of the ions beam used for production of neutrons on the source target by (*,xn) reaction. The preliminary results for neutron yield from different thin target materials are showed in the Tables 1.and 2

Table 1 - Neutron Yield [particles/source particle] - Proton Source 75 Mev

Target Material	value	Std. deviation
Pb	2,7337E-01	2,8157E-03
U	4,8410E-01	9,1010E-03
Th	4,1294E-01	1,7200E-02
Bi	2,5734E-01	2,7278E-03
Li	3,2303E-01	4,0378E-03
Be	1,9552E-01	2,4440E-03
W	2,3791E-01	2,2363E-03
Pb-Bi alloy	2,6995E-01	2,7805E-03

Table 2 - Neutron Yield [particles/source particle] - Deuteron Source 67 Mev

Target Material	value	uncert.
Pb	1,3559E-01	2,1424E-03
U	2,0706E-01	4,3896E-03
Th	1,6485E-01	3,1980E-03
Bi	1,3047E-01	2,0353E-03
Li	4,5409E-01	5,9032E-03
Be	2,7206E-01	4,0809E-03
W	1,3972E-01	2,3752E-03
Pb-Bi alloy	1,3501E-01	1,8632E-03

The number of neutrons escaping from the target's surfaces, normalized per one incident particle was also calculated and the results are presented in the Fig 1 and 2.

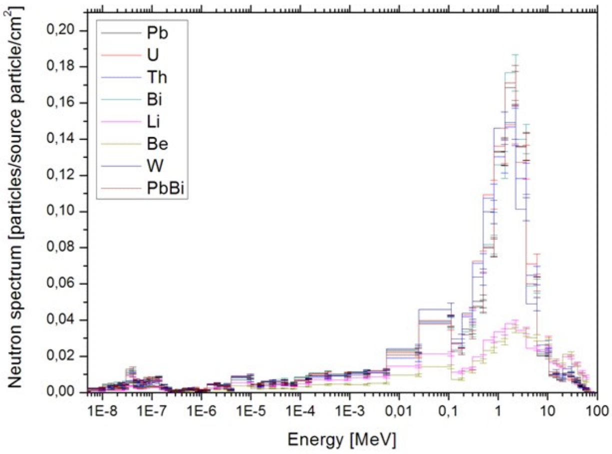

Fig. 1 - Neutron spectrum escaping target's surfaces [particles/source particle/cm^2] - Proton Source 75 Mev

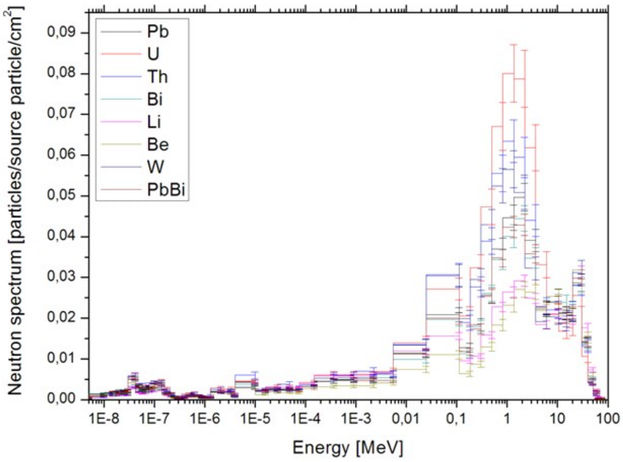

Fig. 2 - Neutron spectrum escaping target's surfaces [particles/source particle/cm^2] - Deuteron Source 67 Mev

2.1.1. CORE RESULTS

The Keff and neutron generation time parameters are shown in Table 3.

	Value	uncert.
Keff	9,8693E-01	2,0000E-05
Λ(seg)	8,5073E-05	7,5099E-07

Table 3 - Keff and neutron generation time(Λ)

It is worth emphasizing that for the calculation of time of life was done by simulating the response of the system by a source of pulsed neutron, i.e., , the response function must be of the form $R = \int S(t)e^{\alpha t}dt$ where it was assumed that $\alpha = \frac{(\rho-\beta)}{\Lambda}$, $\rho = \frac{(k_{eff}-1)}{k_{eff}}$, $\beta = \frac{(k_{eff}-k_{prompt})}{k_{eff}}$.

The neutron spectrum in some positions in the matrix are presented in figures 3 – 6.

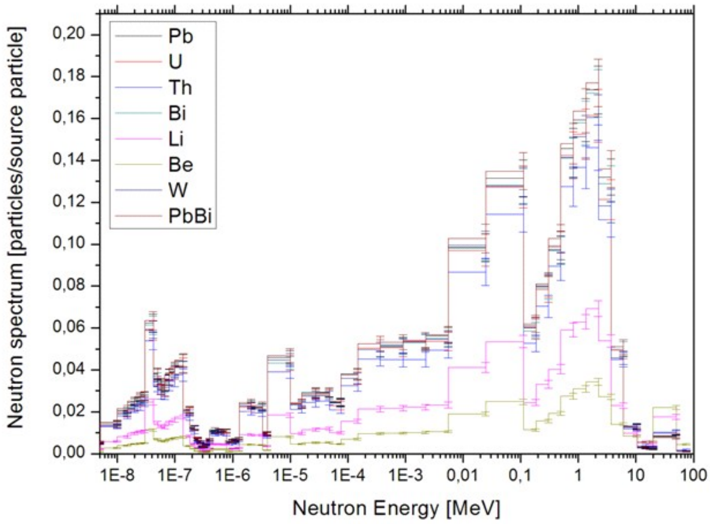

Fig 3 - Neutron spectrum [particles/source particle] - Proton Source 75 Mev - Neutron spectrum averaged in volume of the lattice cells (bellow the target).

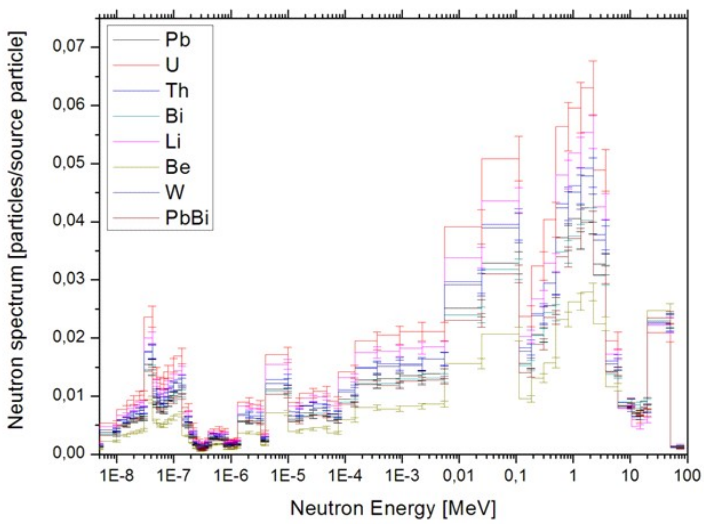

Fig. 4 - Neutron spectrum [particles/source particle] - Deuteron Source 67 Mev – Neutron

spectrum averaged in volume of the lattice cells (bellow the target).

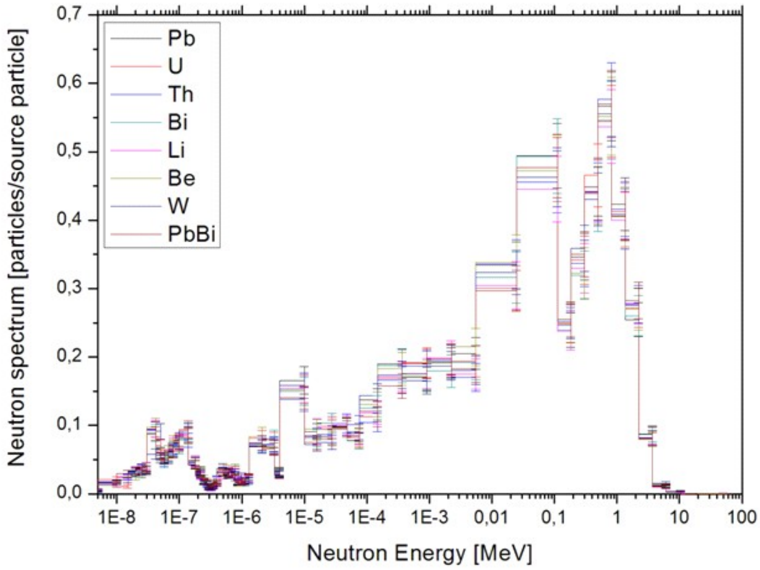

Fig. 5 - Neutron spectrum [particles/source particle] - Proton Source 75 Mev - Neutron spectrum averaged in volume of the lattice cells (at the reflector cell at the tank edge, at the core height of the target).

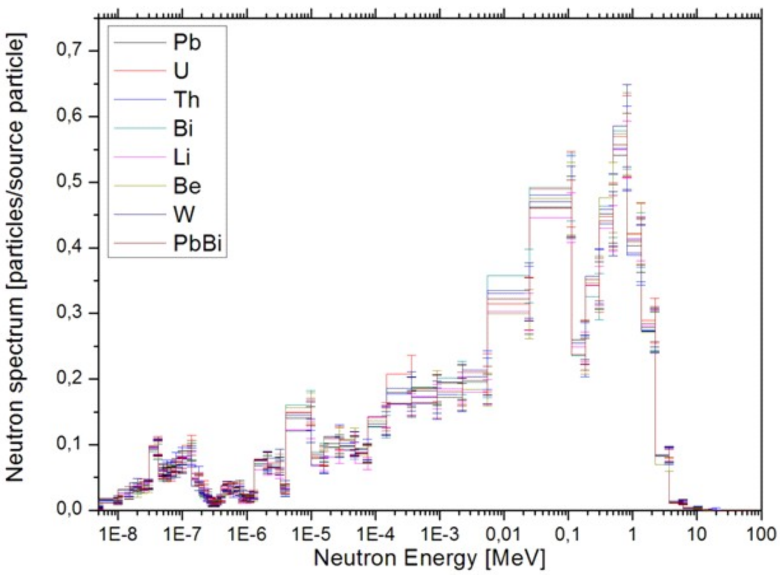

Fig. 6- Neutron spectrum [particles/source particle] - Deuteron Source 67 Mev – Neutron

spectrum averaged in volume of the lattice cells (at the reflector cell at the tank edge, at the core height of the target).

The results presented are preliminary, and they will be compared with experimental data in the Research Coordinate Meeting of the CRP, planned to be held in Vienna [5]

3. CONCLUSIONS

We notice that MCNPX 2.5 provides reasonable results either for thick targets of low energy nuclear reactions, being an useful tool to be used in target design. Also we emphasize that our results are preliminary, and since we are participate in the Analytical Benchmark, we intend to calculate the thick target proposed in the CRP in order to compare with the international community, and validate target calculation methodology in the IPEN. All simulations, for H5b exercise, were performed, leaving only the comparison with numerical and experimental results. The results obtained agree with the numerical results reported by Pesic in a internal work document of IAEA benchmark and the comparison of the results will be published as a IAEA TECDOC, but experimental results are not already avaliable.

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