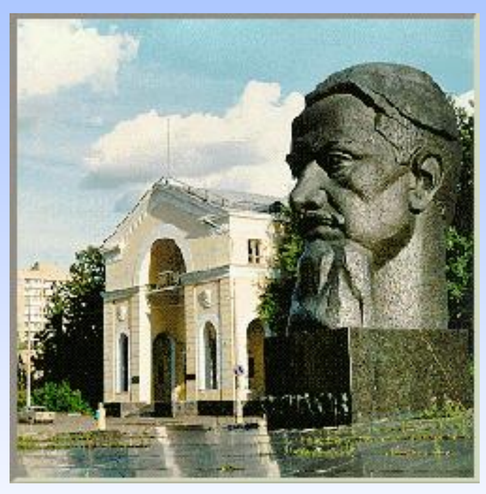

Fusion Neutron Source Blanket: Requirements on Calculation Accuracy and Benchmark Experiment Precision

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Introduction

A conceptual design of a demonstration fusion neutron source (DEMO-FNS) is worked out at the Kurchatov Centre of Nuclear Technologies in the National Research Centre "Kurchatov Institute" [1-4]. There are significant differences between the required and achieved accuracy of calculations of the main DEMO-FNS parameters. The literature is indicated that there is a small number of benchmark experiments with different models of blankets that can be applied to verification of software used for justification of nuclear and radiation safety of the full-scale subcritical blankets.

Objectives and Methods

The virtual absence of the appropriate data has made relevant the problem of preparation and justification of benchmark experiments. A complex composition of nuclides of the blankets and the need to maintain the necessary low level of criticality requires the development of a specific approach to these experiments. For this purpose two types of thorium fusion micro models of the blankets were considered and analyzed. There are a salt and heavy water one.

The MCNP and MCU codes with the ENDF/B-7 point cross-section libraries were used for calculations.

Models

Table. The components and parameters of the Molten Salt (Model I) and Solid Fuel Model (Model II), ØD1xD2 is a major and minor diameter, h is a height

Molten Salt Model (Model I)		Solid Fuel Model (Model II)	
Component	**Parameters**	**Component**	**Parameters**
Source	Ø742x738 mm, h=100 mm, (i) the source that generates only the neutrons with the energy of 14.1 MeV; (ii) (ii) the source based on the proton accelerator with the energy of 24.6 MeV and ^{7}Li target	Source	Ø742x738 mm, h=100 mm, (i) the source that generates only the neutrons with the energy of 14.1 MeV; (ii) (ii) the source based on the proton accelerator with the energy of 24.6 MeV and ^{7}Li target
Coaxial external tank with filler	Ø738x234 mm, h=522 mm, hastelloy	Coaxial external tank with filler	Ø738x234 mm, h=522 mm, Zr
Filler of external tank	D_2O, H_2O, or C	Filler of external tank	D_2O, H_2O, or C
Coaxial internal tank with filler	Ø230x58 mm, h=522 mm, hastelloy	Coaxial internal tank with filler	Ø230x58 mm, h=522 mm, Zr
Filler of internal tank	LiF(67%) + BeF_2(18%) + ThF_4(15%)	Filler of internal tank	D_2O, H_2O, or C
Central rod	Ø55x36 mm, h=522 mm. Consisted of four coaxial bushings composed of hastelloy, Al, $^{6}Li_2O$, Al	Central rod	Ø55x36 mm, h=522 mm. Consisted of four coaxial bushings composed of Zr, Al, $^{6}Li_2O$, Al
Channels with pencil cases inside	Ø25x23 mm, hastelloy; radius from center: r= 46.5, 72.0, and 96.5 mm	Upper and low fuel lattice with two rows of channels for tubes containing ^{232}Th blocks, and detectors in moderator	Zr; radius from center for the first row is 57 mm, and for the second row is 87.5 mm; moderator: D_2O, H_2O, or C
Pencil cases filled with FliBe blocks and detectors	Ø21.5x18.5 mm, hastelloy	Tubes filled with ^{232}Th blocks, and detectors in moderator	Ø25x23 mm, h=492 mm, Zr 12 tubes in internal (I) row, 18 tubes in external (II) row
FliBe blocks	Ø23 mm, h=99.25 mm, LiF(67%) + BeF_2(18%) + ThF_4(15%)	^{232}Th blocks with Al cover	Ø11 mm, h=492 mm, metallic ^{232}Th; thickness of Al cover is 1 mm
Dosimetrical detectors	Ø23 mm, h=25 mm, 14 threshold detectors and 3 additional one (Mn, Lu and Au), which registered 37 products of nuclear reactions.	Dosimetrical detectors	Ø20 mm, h=25 mm, 14 threshold detectors and 3 additional one (Mn, Lu and Au), which registered 37 products of nuclear reactions.

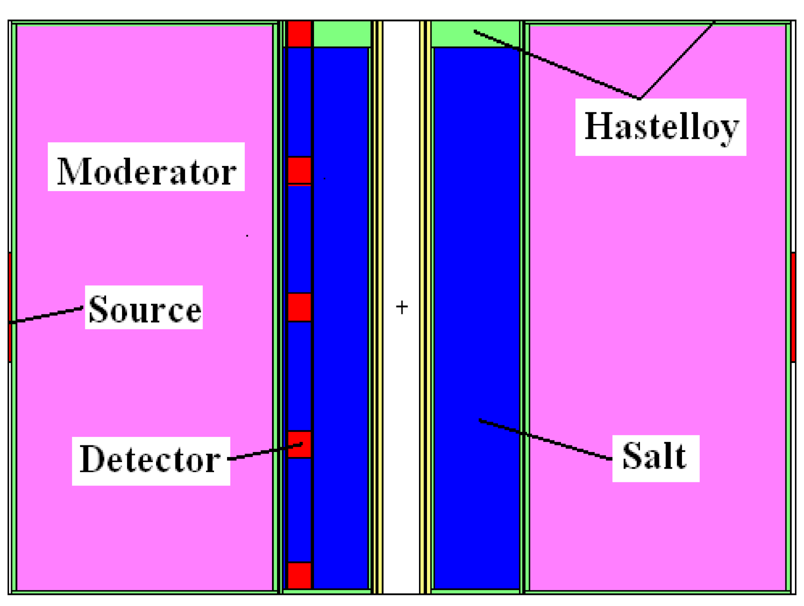

FIG. 1. The vertical cross section view of the molten salt model.

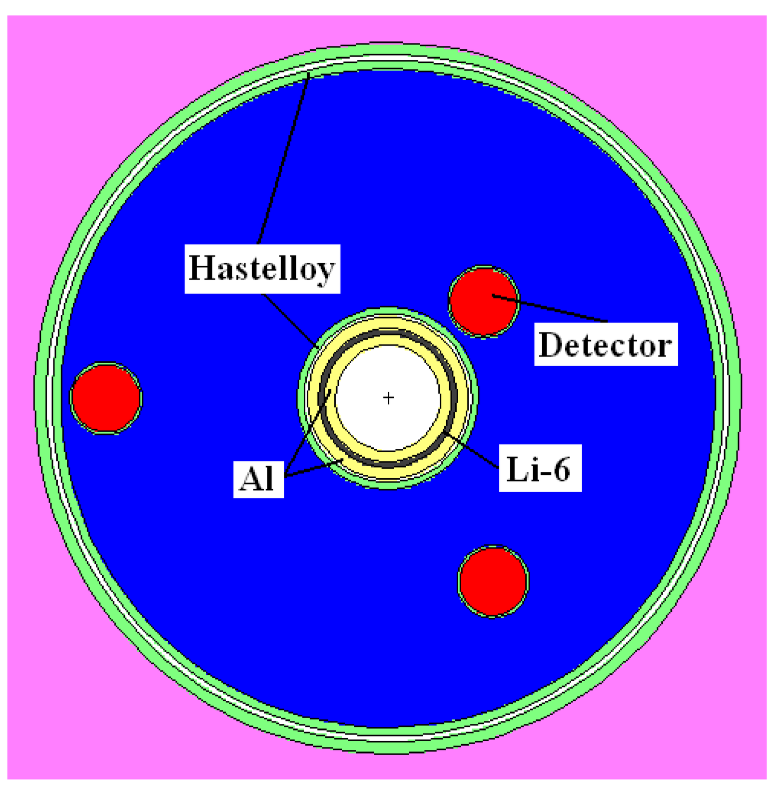

FIG. 2. The central rod and detector locations in the molten salt model.

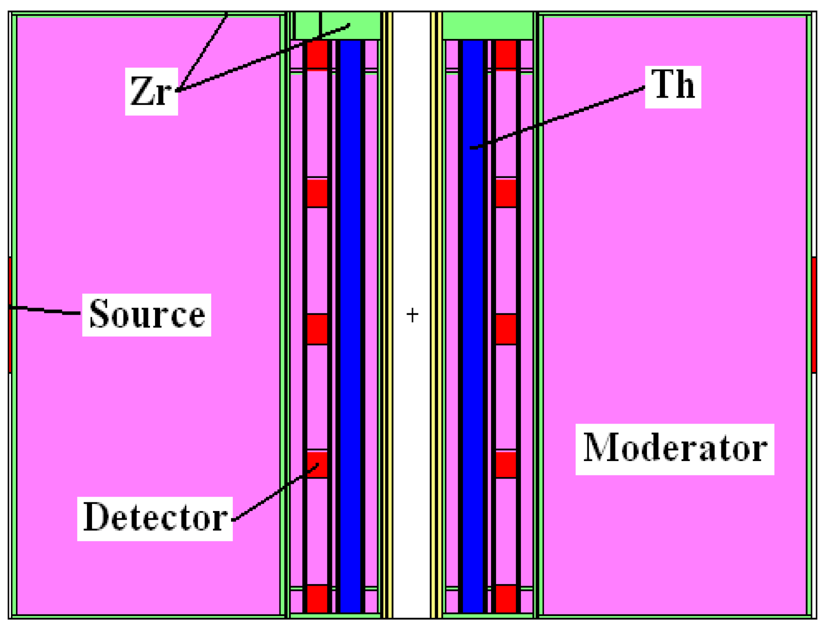

FIG. 3. The vertical cross section view of the solid fuel model.

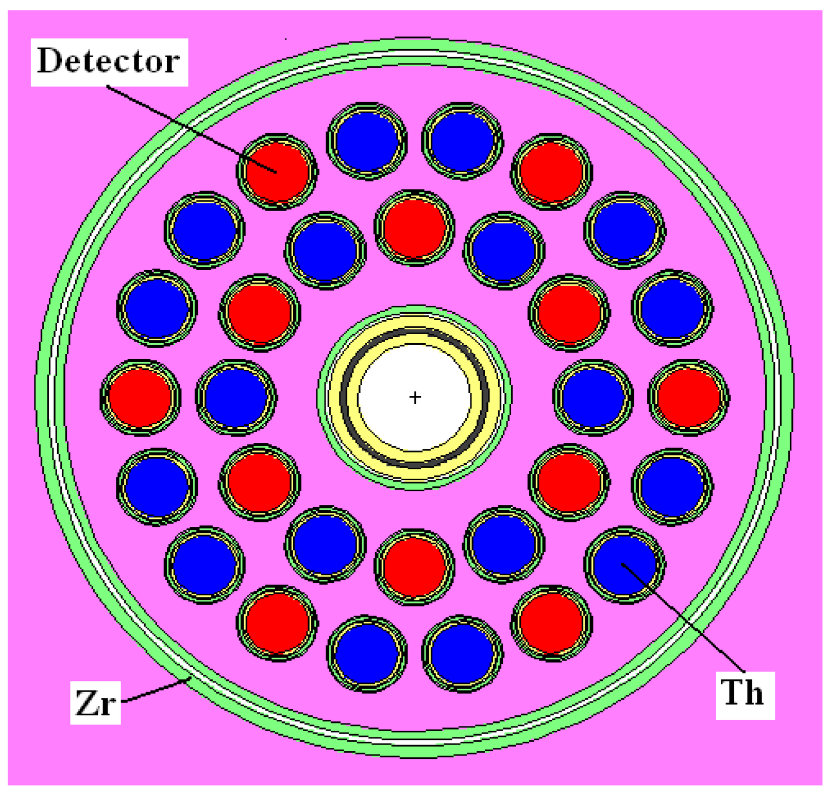

FIG. 4. The locations of thorium channels and detectors in the solid fuel model.

Results

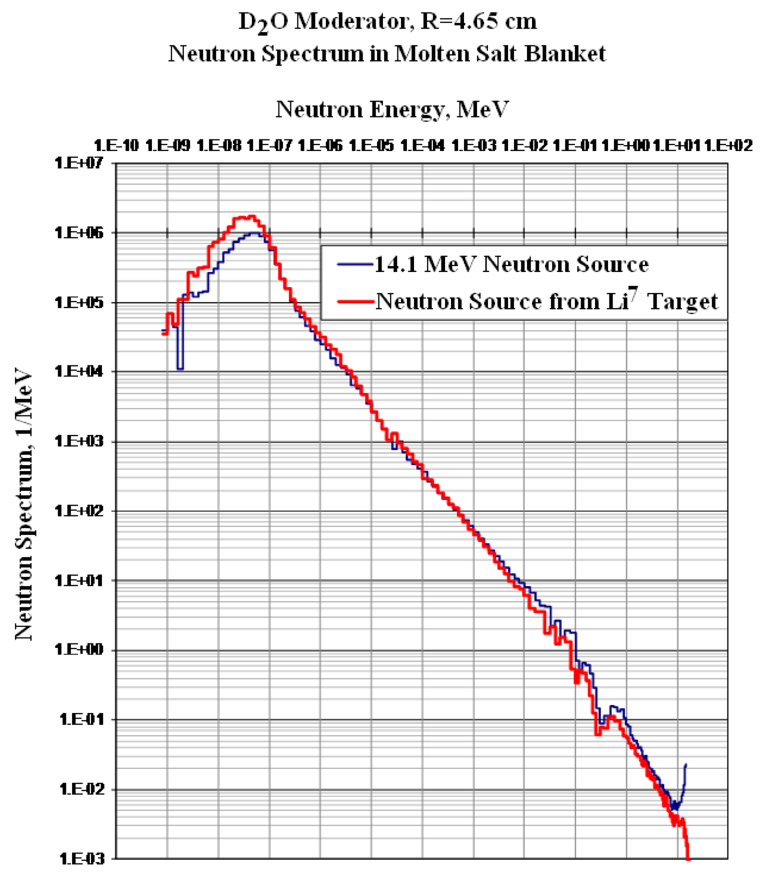

FIG.7. The spectral indexes in the molten salt blanket model with the heavy water moderator.

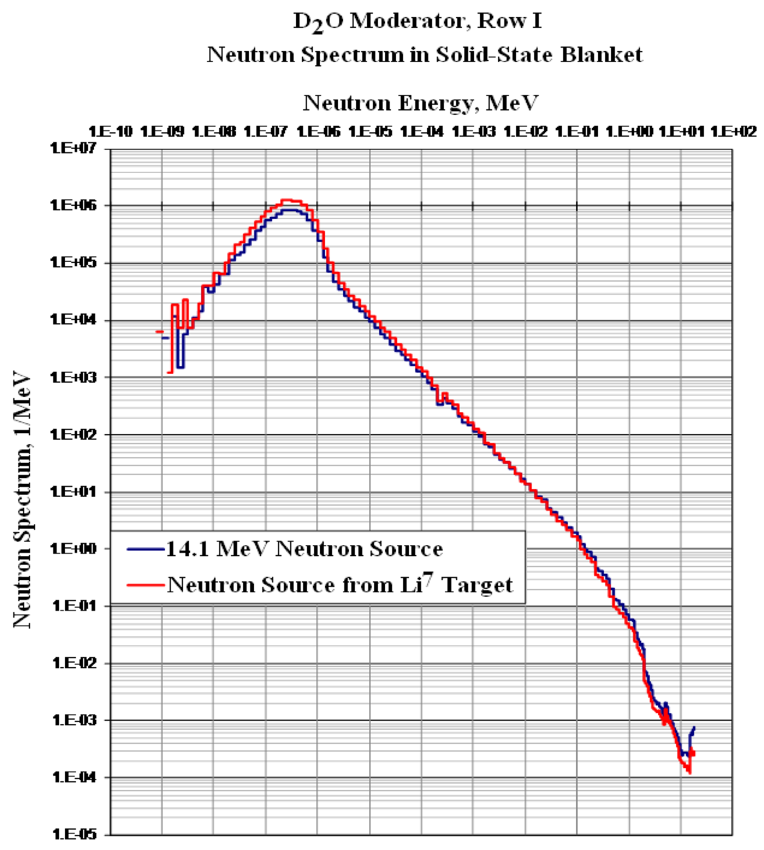

FIG. 8. The spectral indexes in the solid fuel blanket model with the heavy water moderator.

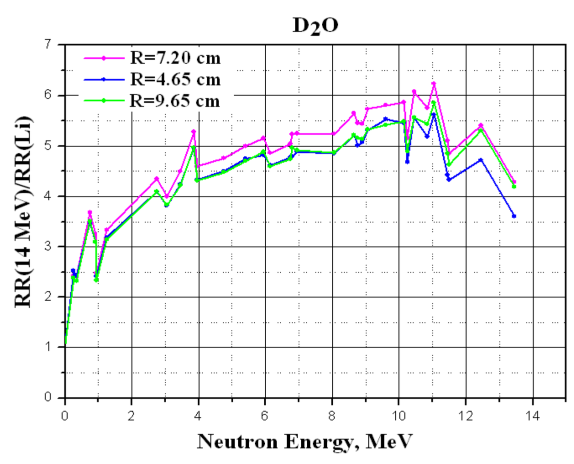

FIG. 5. The energy spectrum in the molten salt blanket model with the heavy water moderator.

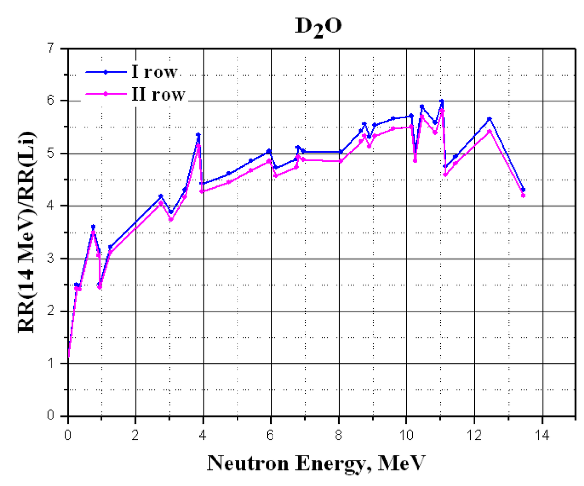

FIG. 6. The energy spectrum in the solid fuel blanket model with the heavy water moderator.

Conclusions

This study is the first step of the development of the benchmark experiment techniques to verify the nuclear data libraries necessary to the DEMO-FNS design. At this stage the technical documentation for fabricating the micro-models of the DEMO-FNS blankets is prepared, the mathematical models of the molten salt and solid fuel blanket are made, and their calculational analysis is performed. The results of the analysis showed the advantage of using the source which generates only the neutrons with the energy of 14.1 MeV over the source based on the proton accelerator. The reason of this is the difference in the calculated spectra for the neutron energies above ~ 100 keV. The increase of the values of the spectral indices quantitatively supports this conclusion.

Acknowledgments

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