CONFERENCE PRE-PRINT

HIGH INTENSITY NEUTRON SOURCE FOR FUSION NUCLEAR TECHNOLOGY DEVELOPMENT

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Abstract

Neutrons play important roles in fusion systems and extended nuclear technology application systems. Neutron sources are important experimental platform for R&Ds of advanced nuclear energy systems and extended nuclear technology applications. FDS Consortium has developed a series of high intensity neutron sources HINEG, which comprise of four phases, HINEG-I, HINEG-II, HINEG-III and VNEG. This contribution reports on the recent progress and applications of HINEG.

1. INTRODUCTION

Neutrons play important roles in nuclear energy. In fusion systems, neutrons are the main energy carriers, trigger tritium breeding reactions and induce problems such as nuclear heat, irradiation damage, nuclear transmutation, activation, radiation exposure, etc. Neutron sources are important experimental platform for related R&Ds. Besides, neutrons also have significant value for extended nuclear technology applications, such as neutron radiography, neutron logging, BNCT, NAA, etc.

FDS Consortium has developed a series of neutron sources for different applications, including the Mini neutron generator MINEG with diameter only 26mm, the Small neutron generator SNEG with size only 1m but neutron intensity ≥1E10 n/s, Compact neutron source CONEG with neutron intensity ≥1E14 n/s, and high intensity neutron source HINEG and Volumetric neutron source VNEG. This contribution reports on the recent progress and applications of those neutron sources.

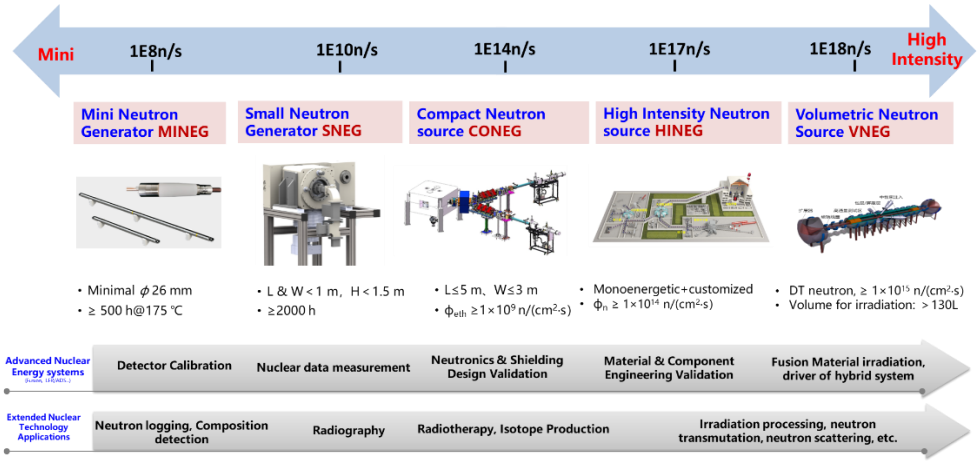


Fig.1 Overview of FDS Series Neutron Sources

2. MINI NEUTRON GENERATOR MINEG

FDS has developed Mini neutron generator MINEG with minimal diameter only 26mm. The neutron yield of Mini neutron generator is over 10^8n/s. The generator has characteristics of high neutron yield, long service life, high temperature resistance, and good anti-vibration performance, and the pulse timing can be flexibly set. It has been applied in neutron logging, elements analysis of materials, security inspection, etc. A full set of production equipment for MINEG has been established and they are ready for mass production.

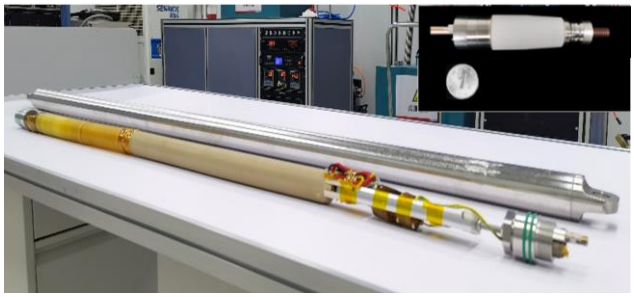
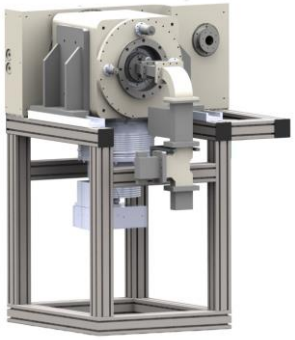


Fig.2 View of Mini neutron generator and neutron tube

3. SMALL NEUTRON GENERATOR SNEG

Small Neutron Generator SNEG is DD/DT neutron sources with characteristics of high neutron yield, long-life time, high safety and reliability, compact design, and movable. It has extensive applications in neutron radiography, NAA for elements analysis, detector calibration, irradiation experiments, nuclear physics experiments, etc.



Performance	Parameters
Size	L & W < 1 m, H < 1.5 m
Neutron yield	10^{10} n/s (DD neutrons) / 10^{12} n/s (DT neutrons)
Neutron energy	2.5/14.1MeV mono energy or moderated thermal or epithermal spectrum
Maintenance interval	≥2000 h, for target replacement
Safety and reliability	No high voltage at the surface of the neutron generator, and support remote operation

Fig.3 Small neutron generator SNEG

4. HIGH INTENSITY NEUTRON SOURCE HINEG

High Intensity Steady Neutron Sources (HINEG) comprise of three phases, HINEG-I, HINEG-II, and HINEG-III. HINEG-II is a high-voltage electrostatic accelerator-based D-T neutron source with neutron yield over 10^{13}n/s, which is built in Chongqing, China. With progress in the development of target technology, ion injecting technology, accelerator technologies, etc., the assembly and commission has been finished periodically, the facility is open for experiments now.

A series of experiments have been performed on HINEG neutron source, such as neutronics performance test of reactor components, shielding performance and activation experiments of materials, validation benchmark experiment for fast and epithermal neutrons shielding and collimation, etc.

Fig.4 High Intensity D-T Neutron Generator HINEG-II

HINEG-III is a large scale scientific facility of steady neutron source characterized with high neutron flux and regulatable neutron spectrum. The designed neutron flux in experimental area is over 10^{14} n/(cm^2 • s). HINEG-III is designed as an irradiation test platform for nuclear fuels, materials and components of advanced nuclear energy systems. It can also be applied as platforms for frontier technology development and extended application research such as isotope production, neutron therapy, silicon doping, etc.

Besides, the compact linear fusion volumetric neutron source VNEG is also under design. The goal of VNEG is to perform full lifetime test for fusion materials and component, collect the reliability data of components, validate radioactive waste transmutation technology. VNEG will be operated at steady-state with ~3MW fusion power and the neutron flux is up to 2 MW/m^2.

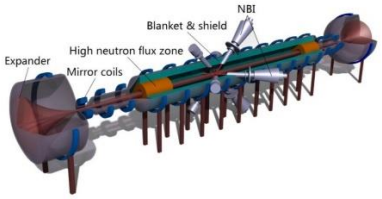


Fig.5 GDT based volumetric neutron source VNEG

ACKNOWLEDGEMENTS

The work was contributed by members from FDS Consortium. HINEG is an open platform to provide high intensity neutron beams. Cooperation and joint researches are welcomed.

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