NEUP Nuclear Energy University Programs
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Project Title

Versatile D-T Neutron-Generation System for Fast-Neutron Research and Education

Applicant Name: The Pennsylvania State University

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ABSTRACT:

In order to stimulate new cutting-edge research and create novel educational tools at the Pennsylvania State University (PSU), we propose to acquire a versatile 14-MeV D-T neutron-generation system. The D-T system consists of two neutron-producing tubes (one tube producing 10^8 neutrons/sec and the other 10^{10} neutrons/sec). The tubes share a single control unit. The lower-neutron-output part of the system will provide a capability to accurately detect the alpha particles resulting from the D-T fusion reaction, thereby allowing for accurate measurements of neutron emission angles and neutron creation times (integrated associated particle imager (API)). Such API-based neutron-generation system is ideal for accurate time-of-flight (energy) and detector characterization experiments. The higher-neutron-output part of the D-T system will be used for applications where the neutron output is more relevant than the neutron emission angle and(or) the neutron creation time. The acquisition of the dual-tube D-T neutron-generation system will enable further expansion of PSU's research and education in the following areas: a) The D-T neutron-generation system will be used for materials irradiation testing and characterization by extending the available neutron energy range at PSU to 14 MeV (1-MW TRIGA nuclear research reactor is available at PSU; it provides neutrons up to ~10 MeV). b) A fast-neutron activation analysis (FNAA) facility will be developed. The FNAA technique will substantially improve the existing neutron activation analysis (NAA) capabilities at PSU by providing a constant-energy fast-neutron beam, and enabling the analysis of large and bulky materials such as candidate structural materials for advanced-reactor concepts, for small modular reactors, and next-generation nuclear-plant demonstrations projects. c) A high-energy neutron imaging facility will be developed for inspections of large-volume and(or) sealed objects up to $\rho x > 100$ g/cm^2, to augment reactor-based fast-neutron irradiation of materials for testing and characterization. The D-T neutron-generation system will be combined with a 6-MeV X-ray imaging system and the resulting fast-neutron/X-ray imaging system will provide unparalleled imaging capabilities (neutrons sensitive to low-Z materials; X-rays sensitive to high-Z materials) for large-volume objects such as gas turbines, car engines, etc. d) The D-T neutron-generation system will be used for fundamental physics research to measure 14-MeV neutron cross-sections for materials relevant for nuclear fusion applications. The 14-MeV cross-sections are paramount for accurate simulations and design of fusion nuclear reactors. e) The D-T neutron-generation system will be used to further expand the existing radiochemistry program, radiation detection and measurements laboratories, and the recently created nuclear security graduate education program. In addition, the 14-MeV neutrons will be used to investigate surrogates for the transmutation of actinides in new-generation nuclear reactors. f) A subcritical graphite reactor is available at PSU and the new D-T system will be used to investigate accelerator-driven subcritical systems. g) The D-T system will be used as a fast-neutron reference source for radiation-detection instrumentation and measurements of electronic-systems behavior in high 14-MeV neutron flux. h) The addition of the D-T neutron-generation system to the existing capabilities will expose PSU students to a range of very important scientific tools. It is expected that over 100 PSU students will be educated annually at the new D-T facility. This facility will greatly support the mission for the education of next-generation nuclear scientists and engineers.