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High-Yield Neutron Source for Cargo Container Screening


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Advanced neutron interrogation techniques offer great promise for the detection of shielded special nuclear materials (SNM) in sea-land cargo containers. Neutrons are able to penetrate cargo and shielding materials and to stimulate SNM signatures, e.g., the emission of delayed gamma-rays and neutrons, that can be detected. Such active interrogation systems require high-yield neutron sources to achieve the desired detection probability, false alarm rate, and throughput. An accelerator-driven neutron source has been designed for a proof of concept system that produces a forward directed beam of high-energy (up to 8.5 MeV) neutrons utilizing the D(d,n)²He reaction. The key components of the neutron source are a high-current radio-frequency quadrupole (RFQ) accelerator and a high-power neutron production target. A D⁺-beam current of up to 40 mA from a microwave-driven deuteron source can be injected into a 5.1 meter-long, 200 MHz RFQ and accelerated to 6 MeV. The RFQ accelerator is capable of operating at a duty factor that produces a time-average beam current of more than 1.2 mA. The beam is transported to a deuterium gas target and spread out to reduce the power density on the target. The critical part of the target is a specially-designed, thin entrance window that minimizes the energy loss of the deuteron beam and can withstand gas pressures exceeding 2 atm. The source will be capable of delivering a neutron flux of >2·10⁷ n/(cm²·s) at a distance of 2.5 m from the target, i.e., near the center of a container, and will enable the comprehensive testing and demonstration of active neutron interrogation.

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