

SHINE's DT Fusion Neutron Source for Radiation Effects Testing

SHINE Technologies operates the Fusion Linear Accelerator for Radiation Effects (FLARE) high flux, steady state, 14 MeV neutron radiation effects testing facility in Janesville, Wisconsin, USA. FLARE is comprised of a neutron generator, a tritium purification system, an irradiation bunker, and related facility infrastructure. The neutron driver and tritium systems are the same technology originally developed for SHINE's NRC licensed isotope production facility. This facility provides DT neutron testing services to customers testing radiation-hardened electronics and nuclear diagnostics. The FLARE facility holds a State of Wisconsin Radioactive Materials license and has been operational since August 2023.

The neutron driver is a linear electrostatic accelerator that ionizes deuterium gas by electron cyclotron resonance (ECR) within a plasma chamber. The ECR source is powered by a motor-generator set and is located within a pressurized vessel containing sulfur hexafluoride as an insulator. The generated deuterium (D2) ions are extracted from the plasma chamber and accelerated by a static electric field (nominally 300 kV) into a drift tube to be transported through a series of vacuum apertures which allow differential pumping from a region of high vacuum to the target chamber, which is filled with a mixture of D2 and tritium (T2) gas.

The tritium system receives mixed D2-T2 gas from the neutron driver, removes trace impurities from the gas stream, performs isotope separation of the mixed gas stream, and provides a controlled flow of high purity tritium to the neutron driver to drive the tritium-deuterium fusion reaction in the target chamber.

An irradiation cavity is installed around the target chamber that is fabricated from aluminum to maximize neutron transport and minimize long-term material activation concerns. The is designed with two independent halves and each half is large enough to simultaneously test numerous components. Because the fusion neutrons are produced from a beam interacting with a gas target, the neutron flux produced from the reaction drops off at a lower rate than $1/r^2$, as would be expected from a point neutron source. Experimental results indicate this rate is approximately $1/r^{1.31}$ for high energy neutrons (>10 MeV). The slower drop of flux allows more of the irradiation cavity to be utilized for device testing than if the neutron source was from a single point.

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